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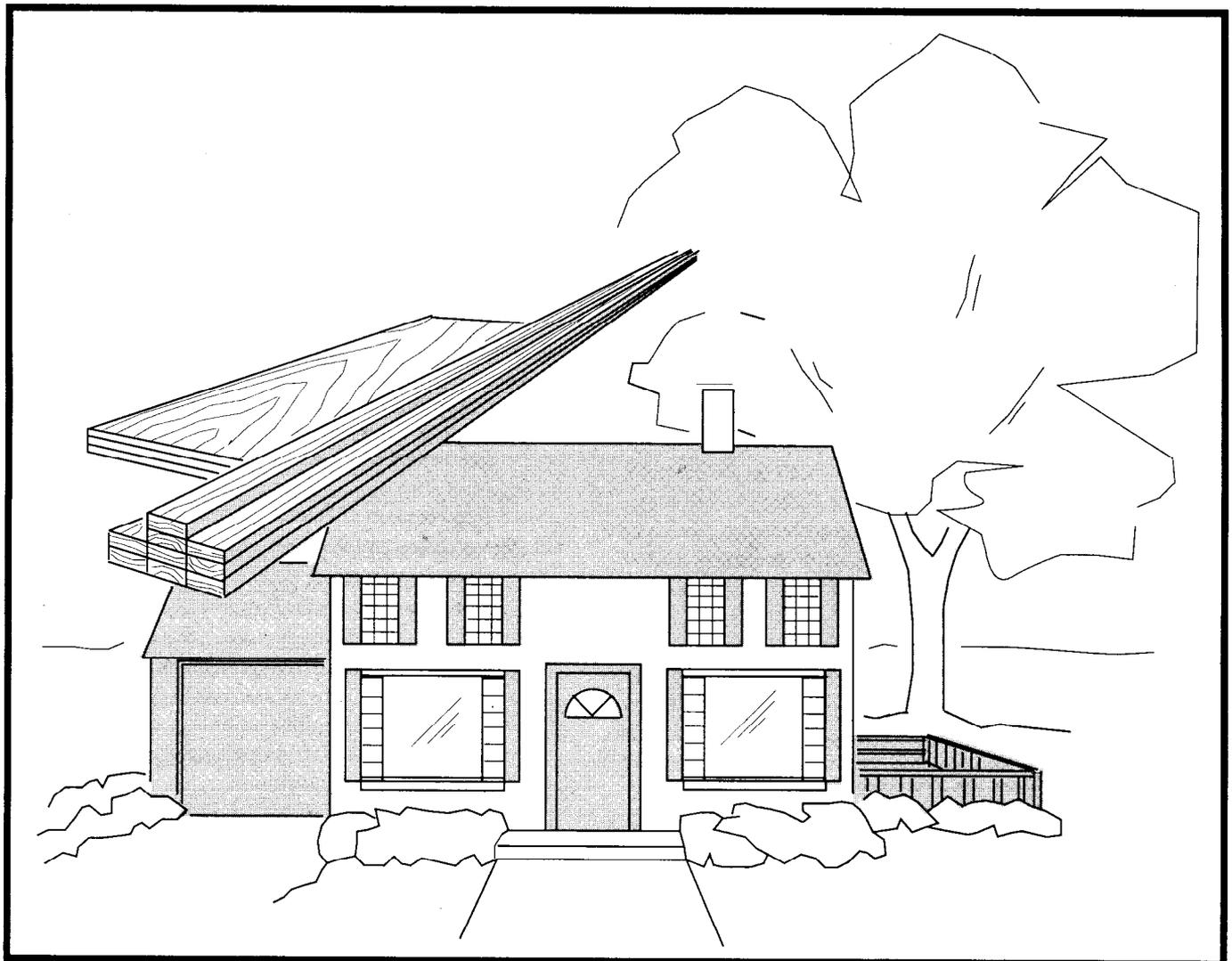
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Wood Products Used for Residential Repair and Remodeling in the United States, 1991

David B. McKeever
Robert G. Anderson



Abstract

Large amounts of lumber and wood panel products are used annually for the repair and remodeling of residential structures and properties in the United States. In response to the need by government and industry for detailed information on this important market for timber products, a study was conducted by the Timber Demand and Technology Assessment Research Work Unit of the USDA Forest Service at the Forest Products Laboratory, Madison, Wisconsin, and the Wood Products Promotion Council, with additional support from the American Plywood Association, Tacoma, WA. Results of this study estimate that the \$97,528 million spent in 1991 for residential repair and remodeling resulted in the consumption of 14,934 million board feet (bf) of lumber, 6,599 million ft², 3/8-in. basis of structural wood panels, and 3,716 million ft², 3/8-in. basis of nonstructural wood panels. The use of wood varied considerably by expenditure type. About one-half of all expenditures were for improvements to the property and the remainder for maintenance and repairs. However, about 85 percent of all wood products were used for improvements. In general, additions, whether to the existing structure or apart (separate) from the structure, were the most wood-intensive activities undertaken; maintenance and repairs were the least wood-intensive. Regional wood products consumption is reported for room and garage additions because regional variations in building types and styles affect consumption. Estimated wood products use per \$1,000 of constant residential repair and remodeling expenditures, by expenditure and project type, is also reported, as is estimated wood products use for millwork and miscellaneous manufactured products.

Keywords: Wood products use, repair, remodeling, upkeep, improvements, end-use consumption

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Wood Products Used for Residential Repair and Remodeling in the United States, 1991

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Introduction

The repair and remodeling of residential structures in the United States is an important market for lumber, wood panels, and products manufactured from wood. Residential structures include single and multiunit structures, both publicly and privately owned; nonfarm and farm properties; and residential properties, whether occupied by owners or renters or vacant (U.S. Department of Commerce, Bureau of the Census 1992). Repair and remodeling include additions and alterations to structures and apart from structures, replacement of major components of the structure, and maintenance and repairs. Prior to the mid-1980s it was believed that wood products use for residential repair and remodeling was about one-half that for new residential construction (U.S. Department of Agriculture, Forest Service 1990). However, since then, many believe consumption for residential repair and remodeling to be rapidly approaching that for new residential construction and may actually exceed that for new single-family housing during the 1990s. In either case, residential repair and remodeling is an important, dynamic market for wood products, one of vital importance to both forest resource planners and the forest products industry.

Despite the importance of residential repair and remodeling as a wood products market, comprehensive studies to enumerate and evaluate the consumption of wood products in this market are not available. Much information on wood products consumption for residential repair and remodeling is based on interpolation and extrapolation from limited, single-product studies, from proprietary studies of limited availability, and from informed "best guess" evaluations.

This study addressed wood products consumption in all aspects of residential repair and remodeling. The study was conducted cooperatively by the Timber Demand and Technology Assessment Research Work Unit of the USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin, and the Wood Products Promotion Council, with additional support from the American Plywood Association, Tacoma, Washington. The Wood Products Promotion Council is a consortium of the American Plywood Association, American Wood Council of the American Forest Products Association (National Forest Products Association), Southern Forest Products Association, and Western Wood Products Association. The types and quantities of lumber, structural wood panels (softwood plywood, oriented strandboard (OSB), and waferboard), and nonstructural wood panels used for residential repair and remodeling in 1991 are estimated by type of expenditure and project. Regional estimates of use are reported for room and garage additions because regional variations in building styles and preferences directly affect wood use. Consumption estimates are derived primarily from expenditures for residential improvements and repairs from the U.S. Department of Commerce, Bureau of the Census (1992), from information provided by George Carter & Associates from a proprietary Resources Information Systems, Inc. (RISI) study of households involved in residential repair and remodeling in 1987 (RISI 1989), and from information collected for a previous study on wood in new residential construction (Anderson and McKeever 1991). Detailed procedures used to estimate wood products consumption are presented in an appendix.

Determinants of Consumption

The consumption of wood products for residential repair and remodeling is largely determined by four major components: (1) level of repair and remodeling activity, (2) type of repair and remodeling project, (3) characteristics of specific project, and (4) amount of wood products used per unit of project activity. Changes within and between each of these components affect wood products consumption over time.

Activity Level

The level of residential repair and remodeling activity in the United States is measured in dollars expended by households and property owners. Expenditures for residential repair and remodeling are collected annually by the U.S. Department of Commerce, Bureau of the Census (1992). Expenditures are stratified into two major types: improvements, and maintenance and repairs. Improvements are further stratified by project type (Fig. 1).

Stratification of expenditures reflects, to some extent, the relative amount of wood used for projects within the stratum. For example, additions to structures typically require large amounts of wood compared to maintenance and repairs. Thus, wood products consumption is affected not only by the overall level of expenditures but by the distribution of expenditures within project types.

Total expenditures for residential repair and remodeling, measured in both current dollars and constant 1987 dollars, rose fairly steadily from the mid-1960s through 1980 (Table 1, Fig. 2). Expenditures fell in 1981 and 1982 and then began a rapid, unprecedented rise in 1983. By 1988, constant dollar expenditures reached a peak of \$97,132 million. Through 1980, total residential repair and remodeling expenditures closely followed the growth in two major economic indicators, gross domestic product (GDP) and disposable personal income (DPI) (Fig. 3) (Council of Economic Advisors 1993). Increases in expenditures after 1980 far exceeded those in GDP and DPI.

The current relationship between residential repair and remodeling expenditures and other economic indicators has markedly changed from established long-term relationships. Many factors have been hypothesized to be responsible for this rapid increase, including rising incomes, aging of the Nation's housing stock, and rapidly rising costs of new house construction in urban areas. The overall impact of increased expenditures for residential repair and remodeling, regardless of the cause, is a larger, stronger, and more dynamic market for all building products, particularly wood.

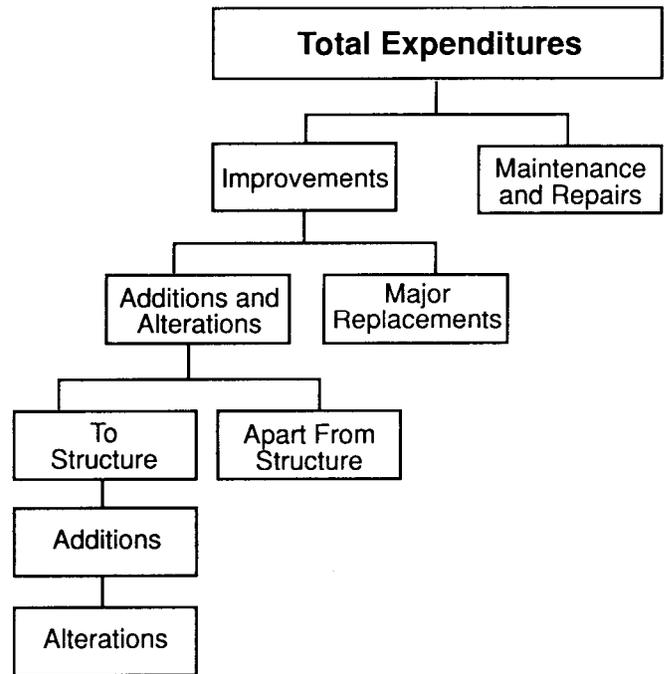


Figure 1—Residential repair and remodeling expenditure types.

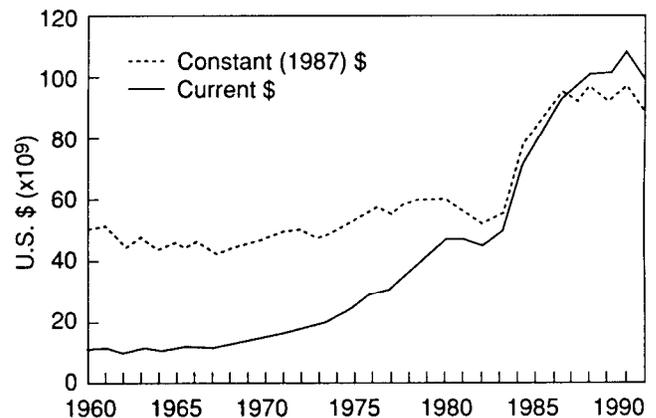


Figure 2—Expenditures for residential repair and remodeling, 1960-1991.

Project Type

A second important determinant of overall wood products consumption for residential repair and remodeling is the type of projects undertaken within each expenditure type. Some projects, such as adding a room, garage, or deck, require large amounts of wood products; others, such as installing new electrical service or replacing a furnace or air conditioner, require little if any wood; still others, such as installing new exterior siding or remodeling an existing room, may or may not require wood products.

For this study, 20 project types were identified and assigned to specific expenditure classes (Fig. 4). Each project type

Table 1—Total expenditures for residential repair and remodeling in the United States, 1960-1991^a

| Year | Expenditure (million U.S.\$) | |
|------|------------------------------|--------|
| | Current | 1987 |
| 1960 | 10,645 | 49,503 |
| 1961 | 11,003 | 51,075 |
| 1962 | 9,772 | 44,569 |
| 1963 | 10,562 | 47,185 |
| 1964 | 10,484 | 42,850 |
| 1965 | 11,442 | 45,333 |
| 1966 | 11,691 | 44,152 |
| 1967 | 11,687 | 42,842 |
| 1968 | 12,703 | 44,146 |
| 1969 | 13,535 | 44,195 |
| 1970 | 14,770 | 46,925 |
| 1971 | 16,299 | 48,963 |
| 1972 | 17,498 | 49,113 |
| 1973 | 18,512 | 47,210 |
| 1974 | 21,114 | 49,010 |
| 1975 | 25,239 | 53,788 |
| 1976 | 29,034 | 58,222 |
| 1977 | 31,280 | 56,545 |
| 1978 | 37,461 | 59,631 |
| 1979 | 42,231 | 59,898 |
| 1980 | 46,338 | 59,514 |
| 1981 | 46,351 | 55,230 |
| 1982 | 45,291 | 52,210 |
| 1983 | 49,295 | 56,206 |
| 1984 | 69,784 | 77,419 |
| 1985 | 80,267 | 87,278 |
| 1986 | 91,274 | 95,281 |
| 1987 | 94,082 | 94,061 |
| 1988 | 101,117 | 97,132 |
| 1989 | 100,891 | 93,039 |
| 1990 | 106,773 | 96,271 |
| 1991 | 97,528 | 87,156 |

^aCurrent dollar expenditures: U.S. Department of Commerce, Bureau of the Census (1981, 1992). Constant dollar expenditures, 1950-1991: Phelps (1992).

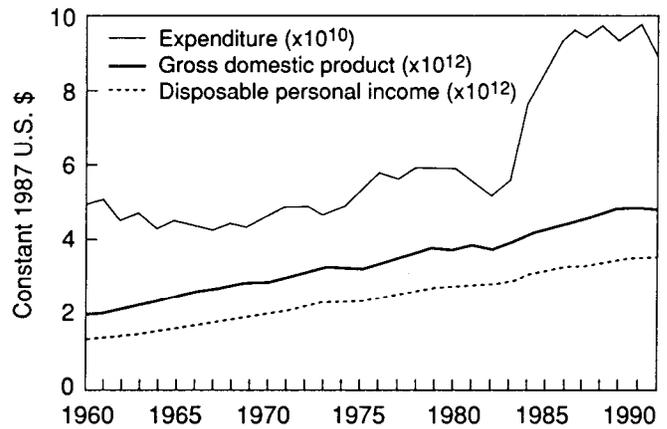


Figure 3—Residential repair and remodeling expenditures, gross domestic product, and disposable personal income, 1960-1991.

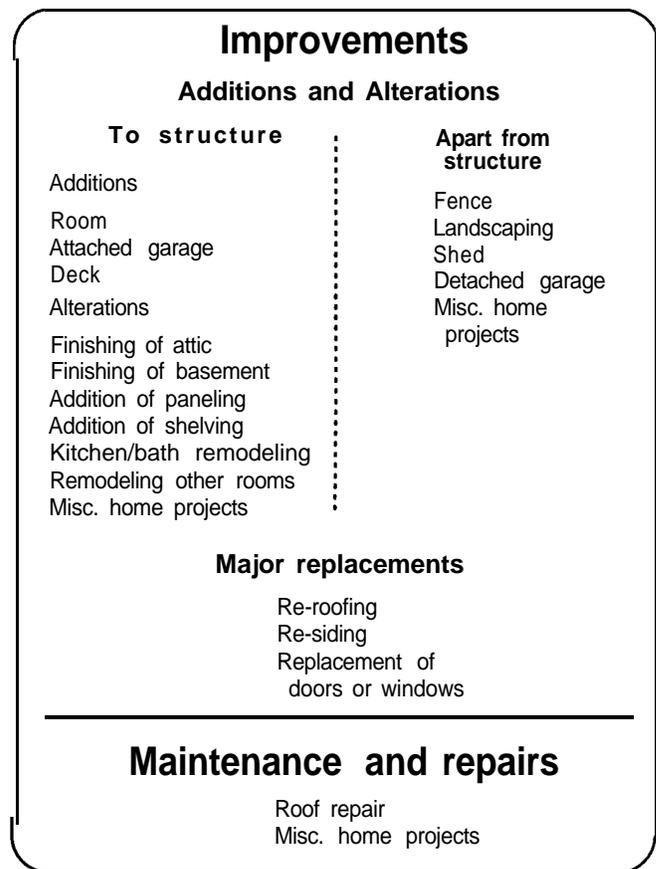


Figure 4—Residential repair and remodeling project types, by type of expenditure.

potentially requires the use of wood products; when combined, the project types account for nearly all the wood used in each expenditure class. As the mix of project types changes over time, as reflected in changes in expenditures within and between expenditure classes, so does the use of wood products. Total wood use is therefore dependent on not only expenditures but also the mix of projects within each expenditure type.

Project Characteristics

Wood consumption is also determined by the specific characteristics of the project. Project characteristics describe in detail how the project was done and include cost, overall size of the project, types of materials used in specific applications within the project, and other information that identifies the presence (incidence) of wood use. For example, for a room addition, exterior wall framing characteristics include the type of exterior walls built (wood framed, nonwood framed, masonry, etc.); the size, length, and spacing of framing members if wood framed; and the total length of exterior walls added. These characteristics are used to develop incidence of use factors. Incidence of use factors describe the average frequency of wood use in a particular project type and activity. When used in conjunction with appropriate wood use factors, estimates of the total volume of wood use can be made.

Incidence of use factors are specific to each project type and application within each project. For room additions, information required includes type of foundation; number of stories; length of attachment to existing building; type of floor framing and decking, wall framing and sheathing, and roof framing and sheathing; exterior finish (siding, fascia, soffit, and roof covering); and millwork (doors, windows, baseboard, cabinets, wall paneling, etc.). Project characteristics and their relationship to wood products consumption are described in detail in the appendix.

Wood Use Per Unit of Activity

The final determinant of total wood consumption is the amount of wood used per unit of activity, commonly referred to as wood use factors. Wood use factors describe in detail the type and quantity of wood used for specific applications within each type of repair or remodeling activity. For exterior wall framing, use factors measure the average amount of dimension lumber used to build wood-framed walls. Use factors are based on the characteristics of the wall built. Specifically, for conventionally framed walls with 2 in. by 4 in. by 8 ft studs placed 16 in. on center (2 by 4/16 studs), the wood use factor is the average volume of lumber required to build 1 linear foot of wall with these characteristics (see Table 2 for SI conversion factors). Incorporated into the use factor are allowances for door and window framing, corners, and other typical variations found in a standard wall. Four basic lumber use factors are needed for exterior wall framing: 2 by 4/16, 2 by 4/24, 2 by 6/16, and 2 by 6/24. These use factors are adjusted to account for variations in wall height and other variations that may affect wood usage.

The units of activity that form the basis for use factors are specific to each project type and application. Units of activity for room addition framing are square feet of finished floor area and linear feet of walls; for door and window replacements, number of standard-size doors and windows; and for miscellaneous home projects, dollars of expenditure.

Table 2—SI conversion factors

| English unit | Conversion factor | SI unit |
|--|-----------------------|-------------------------------|
| board foot (bf) | 0.0024 | cubic meter (m ³) |
| foot (ft) | 0.3048 | meter (m) |
| square foot, 3/8 -in. basis (ft ²) | 0.0009 m ³ | cubic meter (m ³) |
| inch (in.) | 25.4 | millimeter (mm) |

Total Wood Products Consumption

In 1991, residential repair and remodeling used an estimated 14,934 million board feet (bf) of lumber; 6,599 million ft², 3/8-in. basis, of structural wood panels; and 3,716 million ft², 3/8-in. basis, of nonstructural wood panels (Table 3). In this context, lumber includes both softwood and hardwood lumber; structural panels include softwood plywood, OSB and waferboard; nonstructural panels include particleboard, medium-density fiberboard, hardboard, insulation board (fiberboard), and hardwood plywood. Throughout this report, lumber consumption data are reported in board feet (bf), structural and nonstructural wood panel consumption data in industry standard square feet (3/8-in. basis), and expenditure data in constant 1987 dollars, unless otherwise indicated. Of the 6,599 million ft² of structural panels used, 5,565 million ft² (84 percent) were softwood plywood and 1,035 million ft² (16 percent) were OSB/waferboard. On average, 171 bf of lumber, 76 ft² of structural panels (64 ft² of softwood plywood, 12 ft² of OSB/waferboard), and 43 ft² of non-structural panels were used for each \$1,000 spent for repair and remodeling.

Volume estimates reported here include the actual volumes of lumber and panels used, as well as estimated volumes contained in products manufactured elsewhere. Products like kitchen cabinets, bathroom vanities, doors, windows, and other types of millwork and miscellaneous manufactured products are made in industrial plants and shipped to the job site in finished or semifinished form. Although these manufactured products are often accounted for in reports of industrial wood use or manufacturing (e.g., McKeever and Martens 1983), they are ultimately used in residential repair and remodeling projects. Volume estimates are included here for completeness and are also included in the discussion of wood use. Estimates of the volumes of wood contained in millwork and miscellaneous manufactured products used in residential repair and remodeling were made for all projects by expenditure type (Table 4), and for room and garage additions by region (Tables 5 and 6). Wood use for millwork and miscellaneous manufactured products is discussed in the appendix.

Table 3—Constant dollar expenditures and wood products used for residential repair and remodeling by expenditure and project type, 1991

| | Structural panels | | | | | | | | | | | | | |
|---|-------------------|---------------|-----------------------|----------------------------|--------------------|----------------------------|--------------------|----------------------------|--------------------|-----------------------|----------------------------|----------------------|-----------------------|------------|
| | Lumber | | | | Softwood plywood | | OSB/waferboard | | Total | | | Nonstructural panels | | |
| | Expend- iture | Total use | Use/\$1,000 expend | (%) | Total use | Use/ \$1,000 expend | Total use | Use/ \$1,000 expend | Total use | Use/\$1,000 expend | (%) | Total use | Use/\$1,000 expend | (%) |
| (million 1987\$) | (million bf) | (bf) | (%) | (million ft ²) | (ft ²) | (million ft ²) | (ft ²) | (million ft ²) | (ft ²) | (%) | (million ft ²) | (ft ²) | (%) | |
| Improvements | | | | | | | | | | | | | | |
| <i>Additions and alterations</i> | | | | | | | | | | | | | | |
| To structure | | | | | | | | | | | | | | |
| Additions | | | | | | | | | | | | | | |
| Room | — | 2,866 | 405.2 | 46 | 1,536 | 217.2 | 184 | 26.1 | 1,721 | 243.3 | 87 | 499 | 70.5 | 93 |
| Attached garage | — | 215 | 30.4 | 3 | 121 | 17.1 | 23 | 3.3 | 144 | 20.4 | 7 | 37 | 5.2 | 7 |
| Deck | — | 3,109 | 439.6 | 50 | 113 | 15.9 | 0 | 0.0 | 113 | 15.9 | 6 | 0 | 0.0 | 0 |
| Total additions | 7,072 | 6,189 | 875.1 | 100 | 1,770 | 250.3 | 207 | 29.3 | 1,978 | 279.6 | 100 | 535 | 75.7 | 100 |
| Alterations | | | | | | | | | | | | | | |
| Finish attic | — | 186 | 13.0 | 10 | 448 | 31.2 | 55 | 3.8 | 502 | 35.0 | 47 | 88 | 6.2 | 4 |
| Finish basement | — | 388 | 27.0 | 20 | 44 | 3.1 | 0 | 0.0 | 44 | 3.1 | 4 | 156 | 10.8 | 8 |
| Add paneling | — | 68 | 4.8 | 4 | 50 | 3.5 | 0 | 0.0 | 50 | 3.5 | 5 | 297 | 20.6 | 15 |
| Add shelving | — | 131 | 9.1 | 7 | 116 | 8.1 | 0 | 0.0 | 116 | 8.1 | 11 | 371 | 25.9 | 18 |
| Remodel kitchen/bath | — | 189 | 13.2 | 10 | 39 | 2.7 | 0 | 0.0 | 39 | 2.7 | 4 | 668 | 46.5 | 33 |
| Remodel other room | — | 335 | 23.3 | 18 | 44 | 3.0 | 0 | 0.0 | 44 | 3.0 | 4 | 202 | 14.1 | 10 |
| Misc. home projects | — | 611 | 42.5 | 32 | 199 | 13.8 | 78 | 5.4 | 277 | 19.3 | 26 | 237 | 16.5 | 12 |
| Total alterations | 14,366 | 1,909 | 132.9 | 100 | 938 | 65.3 | 132 | 9.2 | 1,071 | 74.5 | 100 | 2,020 | 140.6 | 100 |
| Total, to structure | 21,439 | 8,098 | 377.7 | — | 2,709 | 126.3 | 340 | 15.8 | 3,048 | 142.2 | — | 2,555 | 119.2 | — |
| Apart from structure | | | | | | | | | | | | | | |
| Fence | — | 1,037 | 166.8 | 28 | 48 | 7.7 | 0 | 0.0 | 48 | 7.7 | 4 | 0 | 0.0 | 0 |
| Landscape | — | 812 | 130.6 | 22 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0 | 0.0 | 0 |
| Shed | — | 591 | 95.2 | 16 | 452 | 72.8 | 74 | 11.9 | 526 | 84.7 | 39 | 22 | 3.5 | 10 |
| Detached garage | — | 1,009 | 162.4 | 27 | 496 | 79.8 | 158 | 25.4 | 654 | 105.2 | 49 | 98 | 15.7 | 44 |
| Misc. home projects | — | 264 | 42.5 | 7 | 86 | 13.8 | 34 | 5.4 | 120 | 19.3 | 9 | 102 | 16.5 | 46 |
| Total, apart from structure | 6,214 | 3,713 | 597.4 | 100 | 1,083 | 174.2 | 265 | 42.6 | 1,348 | 216.9 | 100 | 222 | 35.6 | 100 |
| Total, all additions and alterations | 27,653 | 11,811 | 427.1 | — | 3,791 | 137.1 | 605 | 21.9 | 4,396 | 159.0 | — | 2,777 | 100.4 | — |
| Major replacements | | | | | | | | | | | | | | |
| Re-roof | — | 585 | 39.1 | 51 | 601 | 40.2 | 124 | 8.3 | 725 | 48.4 | 67 | 0 | 0.0 | 0 |
| Re-side | — | 317 | 21.2 | 28 | 361 | 24.1 | 0 | 0.0 | 361 | 24.1 | 33 | 135 | 9.0 | 66 |
| Replace door/window | — | 242 | 16.2 | 21 | 2 | 0.2 | 0 | 0.0 | 2 | 0.2 | 0 | 70 | 4.7 | 34 |
| Total replacements | 14,963 | 1,144 | 76.5 | 100 | 964 | 64.4 | 124 | 8.3 | 1,087 | 72.7 | 100 | 205 | 13.7 | 100 |
| Total improvements | 42,617 | 12,956 | 304.0 | — | 4,755 | 111.6 | 728 | 17.1 | 5,484 | 128.7 | — | 2,982 | 70.0 | — |
| Maintenance and repairs | | | | | | | | | | | | | | |
| Roof repair | — | 85 | 1.9 | 4 | 193 | 4.3 | 65 | 1.5 | 258 | 5.8 | 23 | 0 | 0.0 | 0 |
| Misc. home projects | — | 1,893 | 42.5 | 96 | 616 | 13.8 | 241 | 5.4 | 857 | 19.3 | 77 | 734 | 16.5 | 100 |
| Misc. home projects | — | 1,893 | 42.5 | 96 | 616 | 13.8 | 241 | 5.4 | 857 | 19.3 | 77 | 734 | 16.5 | 100 |
| Total | 44,540 | 1,978 | 44.4 | 100 | 810 | 18.2 | 306 | 6.9 | 1,116 | 25.1 | 100 | 734 | 16.5 | 100 |
| | 87,156 | 14,934 | 171.3 | — | 5,565 | 63.8 | 1,035 | 11.9 | 6,599 | 75.7 | — | 3,716 | 42.6 | — |

Table 4—Volume of wood products used for millwork and miscellaneous manufactured products and percentage of total wood products used for residential repair and remodeling by expenditure type, 1991

| Expenditure or project type | Lumber | | Structural panels | | Nonstructural panels | |
|----------------------------------|--------------|------|----------------------------|------|----------------------------|------|
| | (million bf) | (%) | (million ft ²) | (%) | (million ft ²) | (%) |
| Improvements | | | | | | |
| Additions and alterations | | | | | | |
| To structure | | | | | | |
| Addition | 201 | 3.3 | 48 | 2.7 | 190 | 35.5 |
| Alteration | 652 | 34.2 | 281 | 29.9 | 1,724 | 85.4 |
| Total | 854 | 10.5 | 329 | 12.2 | 1,914 | 74.9 |
| Apart from structure | 36 | 1.0 | 17 | 1.6 | 23 | 10.2 |
| Total, additions and alterations | 890 | 7.5 | 347 | 9.1 | 1,937 | 69.8 |
| Major replacements | 379 | 33.1 | 2 | 0.2 | 70 | 34.1 |
| Total, improvements | 1,269 | 9.8 | 349 | 7.3 | 2,007 | 67.3 |
| Maintenance and repairs | 95 | 4.8 | 31 | 3.8 | 37 | 5.0 |
| Total, all expenditure types | 1,363 | 9.1 | 380 | 6.8 | 2,043 | 55.0 |

Consumption by Expenditure Type

Large variations in wood products consumption by expenditure type are the result of differences in total levels of expenditure and differences in the types of repair and remodeling projects included in each expenditure type.

Expenditures were nearly equally divided between improvements, and maintenance and repairs (Table 7). However, about 85 percent of all wood products were used for improvements, with only about 15 percent for maintenance and repairs. Within improvements, additions to structures accounted for just 8 percent of all repair and remodeling expenditures, but 41 percent of lumber, 30 percent of structural panels, and 14 percent of non-structural panels.

Differences between percentage of expenditures and percentage of wood use by expenditure type are directly attributable to the types of projects included in each expenditure type. Room, garage, and deck additions are typically very wood-intensive projects, whereas many maintenance and repair projects do not use wood.

Lumber

Improvements constituted 87 percent (12,956 million bf) of all lumber used in 1991 for residential repair and remodeling; the remaining 13 percent was used for

maintenance and repairs. Eight project types accounted for more than 80 percent of the lumber used for improvements (Fig. 5). Decks and room additions used the greatest percentage of lumber—24 and 22 percent of total lumber use, respectively.

Most of the lumber for improvements was used for additions and alterations (79 percent); about 8 percent was used for major replacements. Within additions and alterations, more than one-half the lumber was used for additions to structures (6,189 million bf) and slightly less than one-third for additions and alterations apart from structures (3,713 million bf) (Table 3). The remainder (1,909 million bf) was used for alterations to structures.

Structural Panels

In 1991, improvements accounted for 83 percent (5,484 million ft²) and maintenance and repairs for 17 percent of all structural panels used for residential repair and remodeling. Six project types accounted for more than 80 percent of the panels used for improvements, with room additions accounting for nearly one-third (Fig. 5).

Additions and alterations accounted for two-thirds of all structural panels used for residential repair and remodeling. The remaining one-third was nearly equally divided between major replacements and maintenance and repairs.

Table 5—Wood products used for room additions and attached or detached garages, by application and region, 1991

| Region | Floors, lofts, and storage areas ^a | | | | | Walls | | | | | Roofs | | | | | Millwork | | | Total, all systems | | | | |
|------------------------|---|-------|-----------------|-------|----------------|--|----------|-----------------|-------|----------------|--|----------|-----------------|-------|----------------|--|----------------|-------------------|--------------------|-----------------|--------|----------|-----------------|
| | Structural panels | | | | Non-structural | Structural panels | | | | Non-structural | Structural panels | | | | Non-structural | Soft-wood ply-wood | Non-structural | Structural panels | | | | | |
| | Lumber | Ply | OSB/wafer-board | Total | | Lumber | Ply-wood | OSB/wafer-board | Total | | Lumber | Ply-wood | OSB/wafer-board | Total | | | | Lumber | Ply-wood | OSB/wafer-board | Lumber | Ply-wood | OSB/wafer-board |
| | | | | | Total panels | | | | | Total panels | | | | | Total panels | | | | | | | | |
| (million bf) | ----- (million ft ²) ----- | | | | (million bf) | ----- (million ft ²) ----- | | | | (million bf) | ----- (million ft ²) ----- | | | | (million bf) | ----- (million ft ²) ----- | | | | | | | |
| Room addition | | | | | | | | | | | | | | | | | | | | | | | |
| North | 287.8 | 293.6 | 39.5 | 333.1 | 33.1 | 607.0 | 162.1 | 45.2 | 207.0 | 81.5 | 622.0 | 329.5 | 23.5 | 353.1 | 4.1 | 111.1 | 13.0 | 98.5 | 1,627.7 | 798.2 | 108.3 | 906.2 | 217.0 |
| South | 91.7 | 104.4 | 19.2 | 123.4 | 6.8 | 277.6 | 89.5 | 13.5 | 103.0 | 90.9 | 290.6 | 182.9 | 23.8 | 206.6 | 4.1 | 43.6 | 34.5 | 63.6 | 703.2 | 409.6 | 56.3 | 465.8 | 163.7 |
| West | 79.3 | 71.4 | 0.0 | 71.7 | 38.0 | 244.5 | 120.6 | 8.6 | 129.5 | 50.7 | 167.8 | 134.3 | 10.9 | 145.2 | 3.3 | 42.6 | 0.6 | 24.1 | 534.6 | 328.6 | 19.7 | 348.7 | 117.9 |
| Total | 458.8 | 469.5 | 58.7 | 528.2 | 77.9 | 1,129.2 | 372.1 | 67.3 | 439.5 | 223.1 | 1,080.3 | 646.7 | 58.2 | 704.9 | 11.4 | 197.3 | 48.1 | 186.2 | 2,865.6 | 1,536.4 | 184.3 | 1,720.7 | 498.7 |
| Attached garage | | | | | | | | | | | | | | | | | | | | | | | |
| North | 0.3 | 1.1 | 0.2 | 1.3 | 0.0 | 18.9 | 7.7 | 6.8 | 14.3 | 1.9 | 44.7 | 15.9 | 5.1 | 20.9 | 0.3 | 0.8 | 0.1 | 0.7 | 64.6 | 24.2 | 11.7 | 35.6 | 2.8 |
| South | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 30.7 | 8.4 | 5.0 | 13.3 | 9.1 | 57.4 | 23.4 | 0.9 | 24.4 | 0.7 | 1.3 | 0.1 | 1.4 | 89.2 | 31.2 | 5.6 | 36.8 | 11.1 |
| West | 1.9 | 23.1 | 5.1 | 28.2 | 5.8 | 23.1 | 12.2 | 0.0 | 12.4 | 14.2 | 34.2 | 28.7 | 0.0 | 28.9 | 0.7 | 2.0 | 0.2 | 1.9 | 61.4 | 65.6 | 5.9 | 71.7 | 22.9 |
| Total | 2.2 | 24.3 | 5.3 | 29.6 | 5.8 | 72.7 | 28.3 | 11.8 | 40.1 | 25.2 | 136.2 | 68.1 | 6.0 | 74.1 | 1.7 | 4.1 | 0.4 | 4.0 | 215.1 | 121.0 | 23.1 | 144.2 | 36.8 |
| Detached garage | | | | | | | | | | | | | | | | | | | | | | | |
| North | 2.9 | 8.6 | 1.8 | 10.4 | 5.7 | 178.8 | 94.7 | 36.5 | 131.0 | 29.4 | 334.9 | 129.2 | 64.2 | 192.9 | 2.4 | 6.1 | 0.7 | 5.9 | 522.6 | 233.4 | 102.5 | 335.2 | 43.4 |
| South | 2.1 | 14.0 | 3.5 | 17.5 | 1.7 | 107.2 | 44.8 | 14.0 | 58.7 | 30.5 | 206.7 | 84.4 | 28.6 | 113.0 | 2.9 | 5.1 | 0.6 | 5.4 | 321.0 | 143.4 | 46.0 | 189.4 | 40.4 |
| West | 0.7 | 5.1 | 0.0 | 5.2 | 0.0 | 74.2 | 54.1 | 8.9 | 63.1 | 6.5 | 85.8 | 59.5 | 0.0 | 60.1 | 1.6 | 4.5 | 0.5 | 5.4 | 165.4 | 119.4 | 9.1 | 129.2 | 13.6 |
| Total | 5.8 | 27.7 | 5.3 | 33.1 | 7.5 | 360.2 | 193.5 | 59.4 | 252.9 | 66.3 | 627.3 | 273.1 | 92.8 | 366.0 | 6.9 | 15.7 | 1.8 | 16.7 | 1,009.0 | 496.2 | 157.6 | 653.8 | 97.5 |

^aIncludes room addition floors, end garage lofts end storage areas.

Table 6—Wood products used for room additions and attached or detached garages per \$1,000 (1987) of expenditure for additions to structures, by application and region, 1991^a

| Re- gion | Floors, lofts, and storage areas ^b | | | | | Walls | | | | | Roofs | | | | Millwork | | | Total, all systems | | | | | |
|------------------------|---|------------------------------|--|-------|-----------------------------------|-------------------|------------------------------|--|-------|-----------------------------------|-------------------|------------------------------|--|-------|-----------------------------------|--------|--------------|-----------------------------------|--------|--------------|-------|-------|-----------------------------------|
| | Structural panels | | | | | Structural panels | | | | | Structural panels | | | | | | | Structural panels | | | | | |
| | Lumber | OSB/ Ply- wafer- board | | Total | Non- struct- ural panels | Lumber | OSB/ Ply- wafer- board | | Total | Non- struct- ural panels | Lumber | OSB/ Ply- wafer- board | | Total | Non- struct- ural panels | Lumber | Ply- wood | Non- struct- ural panels | Lumber | Ply- wood | board | Total | Non- struct- ural panels |
| | | (million bf) | ----- (million ft ²) ----- | | | | (million bf) | ----- (million ft ²) ----- | | | | (million bf) | ----- (million ft ²) ----- | | | | | | | | | | |
| Room addition | | | | | | | | | | | | | | | | | | | | | | | |
| North | 81.4 | 83.0 | 11.2 | 94.2 | 9.4 | 171.7 | 45.8 | 12.8 | 58.5 | 23.0 | 175.9 | 93.2 | 6.7 | 99.9 | 1.2 | 31.4 | 3.7 | 27.9 | 460.3 | 225.7 | 30.6 | 256.3 | 61.4 |
| South | 44.7 | 50.9 | 9.4 | 60.2 | 3.3 | 135.4 | 43.6 | 6.6 | 50.2 | 44.3 | 141.7 | 89.2 | 11.6 | 100.7 | 2.0 | 21.3 | 16.8 | 31.0 | 342.9 | 199.7 | 27.5 | 227.1 | 79.8 |
| West | 53.4 | 48.1 | 0.0 | 48.3 | 25.6 | 164.7 | 81.2 | 5.8 | 87.2 | 34.1 | 112.9 | 90.4 | 7.3 | 97.8 | 2.2 | 28.7 | 0.4 | 16.2 | 360.0 | 221.3 | 13.3 | 234.8 | 79.4 |
| Total | 64.9 | 66.4 | 8.3 | 74.7 | 11.0 | 159.7 | 52.6 | 9.5 | 62.1 | 31.5 | 152.8 | 91.4 | 8.2 | 99.7 | 1.6 | 27.9 | 6.8 | 26.3 | 405.2 | 217.2 | 26.1 | 243.3 | 70.5 |
| Attached garage | | | | | | | | | | | | | | | | | | | | | | | |
| North | 0.08 | 0.31 | 0.06 | 0.37 | 0.00 | 5.35 | 2.17 | 1.93 | 4.04 | 0.53 | 12.63 | 4.50 | 1.45 | 5.91 | 0.08 | 0.22 | 0.02 | 0.20 | 18.26 | 6.85 | 3.30 | 10.07 | 0.79 |
| South | 0.01 | 0.05 | 0.01 | 0.06 | 0.00 | 14.94 | 4.12 | 2.43 | 6.51 | 4.45 | 27.97 | 1.43 | 0.42 | 11.88 | 0.35 | 0.66 | 0.05 | 0.70 | 43.50 | 15.23 | 2.71 | 17.94 | 5.39 |
| West | 1.25 | 15.55 | 3.42 | 18.97 | 3.92 | 15.57 | 8.18 | 0.00 | 8.38 | 9.59 | 23.00 | 9.36 | 0.00 | 19.43 | 0.45 | 1.32 | 0.12 | 1.28 | 41.32 | 44.14 | 3.98 | 48.30 | 15.44 |
| Total | 0.31 | 3.44 | 0.75 | 4.19 | 0.82 | 10.28 | 4.00 | 1.67 | 5.67 | 3.57 | 19.26 | 9.63 | 0.85 | 10.48 | 0.24 | 0.58 | 0.05 | 0.57 | 30.42 | 7.11 | 3.27 | 20.38 | 5.20 |
| Detached garage | | | | | | | | | | | | | | | | | | | | | | | |
| North | 1.0 | 2.8 | 0.6 | 3.4 | 1.9 | 57.8 | 30.6 | 11.8 | 42.4 | 9.5 | 108.3 | 41.8 | 20.8 | 62.3 | 0.8 | 2.0 | 0.2 | 1.9 | 168.9 | 75.4 | 33.1 | 108.4 | 14.0 |
| South | 1.2 | 7.8 | 2.0 | 9.8 | 1.0 | 59.8 | 25.0 | 7.8 | 32.8 | 17.0 | 115.3 | 47.1 | 16.0 | 63.1 | 1.6 | 2.8 | 0.3 | 3.0 | 179.1 | 80.0 | 25.6 | 105.7 | 22.6 |
| West | 0.5 | 3.9 | 0.0 | 3.9 | 0.0 | 55.9 | 40.7 | 6.7 | 47.5 | 4.9 | 64.5 | 44.8 | 0.0 | 45.2 | 1.2 | 3.4 | 0.4 | 4.1 | 124.5 | 89.9 | 6.9 | 97.2 | 10.3 |
| Total | 0.9 | 4.5 | 0.9 | 5.3 | 1.2 | 58.0 | 31.1 | 9.6 | 40.7 | 10.7 | 100.9 | 44.0 | 14.9 | 58.9 | 1.1 | 2.5 | 0.3 | 2.7 | 162.4 | 79.8 | 25.4 | 105.2 | 15.7 |

^aRoom additions and attached garages based on expenditures for additions to structures; detached garages based on expenditures for additions and alterations apart from structure.

^bIncludes room addition floors, and garage lofts and storage areas.

Table 7—Percentage of expenditures and wood products used for residential repair and remodeling, by expenditure type, 1991

| Expenditure type | Expenditure | Lumber | Structural panels | Non-structural panels |
|-------------------------------------|-------------|--------|-------------------|-----------------------|
| Improvements | | | | |
| Addition or alteration to structure | | | | |
| Addition | 8.1 | 41.4 | 30.0 | 14.4 |
| Alteration | 16.5 | 12.8 | 16.2 | 54.4 |
| Total | 24.6 | 54.2 | 46.2 | 68.8 |
| Apart from structure | | | | |
| Total additions and alterations | 31.7 | 79.1 | 66.6 | 74.7 |
| Major replacements | 17.2 | 7.7 | 16.5 | 5.5 |
| Total improvements | 48.9 | 86.8 | 83.1 | 80.3 |
| Maintenance and repairs | 51.1 | 13.2 | 16.9 | 19.7 |
| Total, all expenditure types | 100.0 | 100.0 | 100.0 | 100.0 |

Overall, with the exception of additions to structures, which accounted for 30 percent (1,978 million ft²), structural panel consumption was fairly evenly distributed among all expenditure types—less than 20 percent was used for each type (Table 3). Use patterns between expenditure types within additions and alterations were similar to those for lumber.

Softwood plywood was the preferred structural panel for residential repair and remodeling. Overall, softwood plywood accounted for 84 percent of all structural panels consumed and OSB/waferboard for 16 percent. This compared to industry production of 77 percent softwood plywood and 23 percent OSB/waferboard (Anderson and Adair 1992). Softwood plywood was used for nearly 90 percent of all panels used for additions to structures and 87 percent of panels used for major replacements, and about 73 percent of panels used for maintenance and repairs.

Nonstructural Panels

Eighty percent (2,982 million ft²) of all nonstructural panels used in 1991 for residential repair and remodeling was for improvements; the remaining 20 percent was for maintenance and repairs. Seven project types accounted for more than 80 percent of the nonstructural panels used for improvements (Fig. 5); kitchen and bathroom remodeling, and room additions accounted for more than one-third of total panels used for improvements.

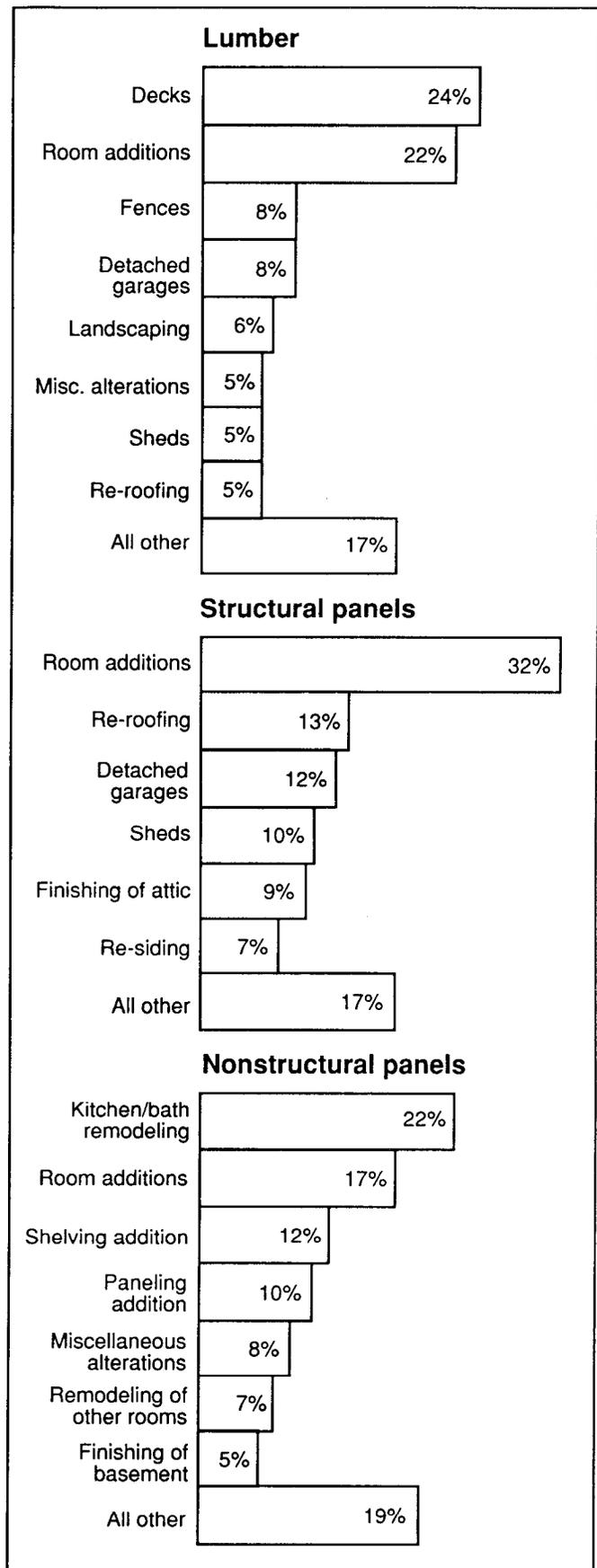


Figure 5—Major project types accounting for ≥80 percent total use for residential repair and remodeling, 1991.

As with lumber and structural panels, more nonstructural panels were used for additions and alterations than for any other activity type, accounting for nearly 75 percent of total use. The remaining volume was used for major replacements (6 percent) and maintenance and repairs (20 percent). The distribution of use within additions and alterations was dramatically different from that for lumber and structural panels. Nearly three-fourths of the nonstructural panels for additions and alterations was used for alterations to structures, primarily as a result of millwork-intensive projects, such as kitchen and bathroom remodeling and interior wall paneling, which are included in alterations. These projects typically use large amounts of doors, cabinets, interior wall paneling, and shelving, all of which contain large amounts of nonstructural panels.

Overall, more than one-half (54 percent) of all nonstructural panels were used for alterations to structures (2,020 million ft²) (Table 3). Within the remaining expenditure types, 20 percent of total nonstructural panel consumption was for maintenance and repairs (734 million ft²); lesser amounts were consumed in the remaining expenditure types.

Estimates of nonstructural panel use by type of panel were not made as a result of data limitations, potential confusion by respondents between OSB/waferboard and particleboard, and differences in standard reporting units for the different panel types. In general, particleboard was principally used for cabinets, shelving, and floor underlayment; hardboard for exterior siding and interior door skins; insulation board for exterior wall sheathing; and hardwood plywood for interior wall paneling. Many panel types were used interchangeably or in combination in many applications, such as kitchen cabinets and interior doors.

Consumption per \$1,000 of Expenditure

One measure of the relative contribution of each expenditure type to total wood products consumption is the amount of wood products consumed per \$1,000 of expenditure. These statistics not only show the amount of wood products used per unit of activity but also help identify markets where wood products consumption can be more readily increased. They also enable the estimation of future levels of wood products consumption based on expected levels of expenditures.

Differences between wood use per \$1,000 of expenditure by expenditure type follow closely differences in actual consumption. In general, with the exception of maintenance and repairs, the larger the amount of wood products used, the higher the use per \$1,000 of expenditure.

An estimated 875.1 bf of lumber was used per \$1,000 of expenditures for additions to structures in 1991 (Table 3, Fig. 6)—more than any other expenditure type and nearly

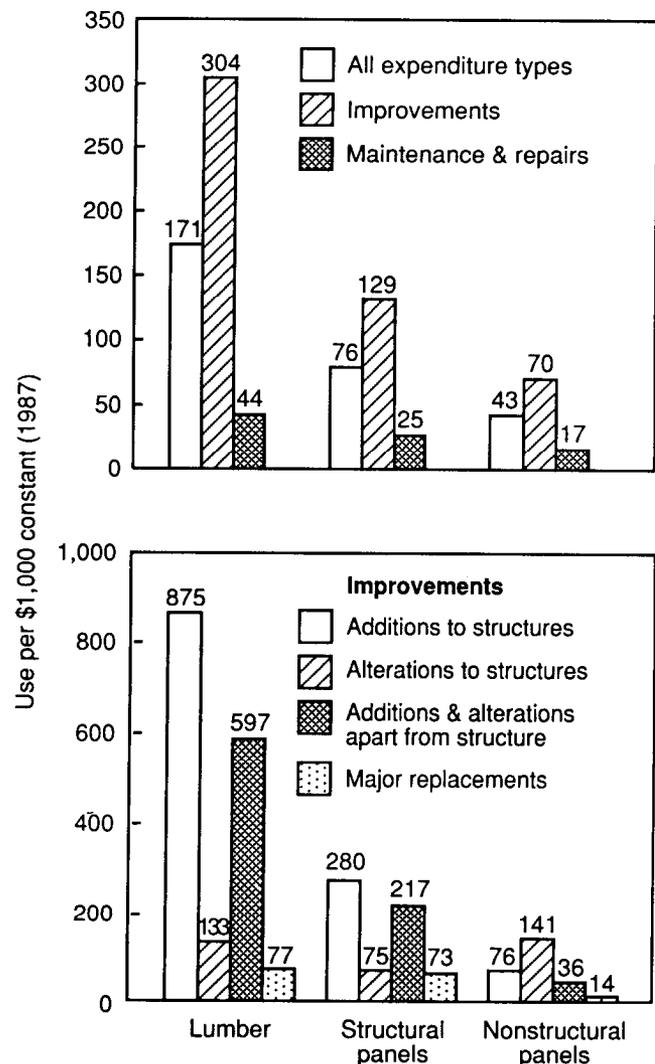


Figure 6—Wood use per \$1,000 of expenditure for residential repair and remodeling, 1991. Lumber data are in board feet and panel data in industry standard square feet, 3/8 in. basis.

50 percent more than the lumber used for additions and alterations apart from structures, the second highest expenditure type. Considerably less lumber was used in the remaining expenditure types. Structural panel use per \$1,000 was also highest for additions to structures and for additions and alterations apart from structures (279.6 and 216.9 ft², respectively), with the difference between these amounts considerably less than that for lumber. Alterations to structures used more nonstructural panels (140.6 ft²) per \$1,000 than any other expenditure type.

Wood products use per \$1,000 of expenditures provides a convenient means of estimating future levels of wood products consumption for residential repair and remodeling. Assuming that the mix of project types within residential repair and remodeling does not change dramatically over the estimation period and that relatively the same amounts of

wood are used per unit of activity, consumption for a specific wood product can be estimated as the sum of the product of wood use per \$1,000 multiplied by constant dollars of expenditure by expenditure type. These estimates can be revised as new information becomes available on types of projects, use of wood and competing materials for these projects, and shifts between expenditures.

Consumption by Expenditure and Project Type

Wood products consumption for residential repair and remodeling is dependent on not only the level of expenditures for this activity but also the type of projects. Wood use per \$1,000 of expenditure can vary by a magnitude of 200 or more between project types. Wood products use in each of the 20 types of projects identified in this study, grouped by expenditure type, is discussed in detail in this section.

Data on 1991 expenditures for each project type are given in Table 3. Expenditures for individual project types used in this study are not available from the U.S. Department of Commerce. Therefore, wood use by project type divided by expenditures by expenditure type is used as a relative measure of the contribution of each project type to its expenditure type.

Additions and Alterations to Structures

Expenditures for additions and alterations to structures totaled \$21,439 million. About one-third of this amount was for additions and the remainder for alterations. These expenditures translate into a total of 8,098 million bf of lumber, 3,048 million ft² of structural panels, and 2,555 million ft² of nonstructural panels. As previously indicated, additions tend to use more lumber and structural panels than do alterations, whereas alterations tend to use more nonstructural panels. This is evidenced by the fact that additions used about three-fourths the lumber and two-thirds the structural panels but only about one-fifth the nonstructural panels. In terms of use per \$1,000 of expenditure, additions used more than twice as much lumber and just under twice as many structural panels than all additions and alterations to structures, but only about two-thirds the amount of nonstructural panels (875.1 bf of lumber, 279.6 ft² of structural panels, and 75.7 ft² of nonstructural panels).

Projects included in additions and alterations to structures are those that add new space or enlarge existing space for rooms, attached garages, or decks, or that alter existing living space by finishing an existing attic or basement, by remodeling an existing kitchen, bathroom, or other room, by the addition of paneling or shelving, or by means of other miscellaneous projects. These projects all have potential for using wood

products, and were examined in detail. Other types of projects that typically do not use wood products, such as adding new electrical outlets or insulating an attic, were not examined. Projects under the category additions and alterations use more than one-half the lumber, nearly one-half the structural panels, and about two-thirds the nonstructural panels used for all residential repair and remodeling.

Room Additions

The addition of rooms to existing structures was by far the single largest use for wood products in residential repair and remodeling in 1991. (Although deck additions used more lumber, the combined use of lumber, structural panels, and nonstructural panels for room additions exceeded the combined use for decks.) Nearly 2,866 million bf of lumber, 1,721 million ft² of structural panels, and 499 million ft² of nonstructural panels were used to build approximately 2.8 million new rooms (Tables 3 and 4). These figures are based on 2.6 million additions to owner-occupied residences (Ahluwalia 1993) and an estimated 0.2 million to other types of residences. These volumes are equivalent to the building of more than 200,000 new houses. (Based on the average amount of wood products used to build a new single-family house in 1988 less the volume of wood used for garages, carports, porches, and decks; assumes an average house size of 2,167 ft² of floor area (McKeever and Anderson 1992)).

Room additions are defined as structural additions to the existing residence to add new space. Typically, this new space can be added by either extending the present foundation of the structure or by adding another story or level to the structure. Excavation of an existing crawl space to create a basement is also included, although no such projects were encountered in this study. Excluded are additions to living space through the conversion of nonliving space to living space, such as converting an existing basement, attic, garage, or carport to living space. Conversions are discussed later in this report.

Room additions accounted for 46 percent (405.2 bf) of the lumber, 87 percent (243.3 ft²) of the structural panels, and 93 percent (70.5 ft²) of the nonstructural panels used per \$1,000 of expenditure for all additions to structures.

Standard building practices and codes are used for both adding rooms to existing structures and for building new structures. If characteristics of a particular building application are known, little variation exists in the amount of building products required for that application. For example, an exterior wall with 2- by 4-in. studs spaced 16 in. on center requires about the same amount of wood per linear foot whether or not the wall is for a room addition or for a new house. Slight variations may be caused by openings for doors and windows, number of corners, and additional bracing. These variations are largely independent of the type of residential structure. For this reason, estimation of wood products used for room additions followed closely the

procedures used to estimate wood products used for new residential construction (Anderson and McKeever 1991).

Because building styles and preferences vary by region and affect wood products use, room additions were divided into three geographical regions—North, South, and West (Fig. 7). These regions correspond to the U.S. Department of Commerce, Bureau of the Census regions; the Northeast and Midwest regions are combined to form the North region.

Wood use factors for floors, walls (exterior and interior), roofs, and millwork applications for room additions were developed from information collected on new residential construction. Wood use factors are defined here to be the volume of lumber, structural panels, or nonstructural panels used on average per unit of activity for specific building applications. For example, the lumber use factor for exterior wall framing with 2- by 4-in. studs spaced 16 in. on center averaged 1.32 bf of lumber for each linear foot of wall built. The use factors were modified to account for differences between new construction and additions. For example, use factors for new residential construction were based on square feet of finished floor area. As such, their use would overestimate wood use for exterior wall framing, sheathing, and siding in room additions because additions generally have only three exterior walls, whereas new houses have four. Conversely, room additions are generally smaller than new houses. Since the ratio of the perimeter to the area of a small object (room addition) is larger than that for a large object (new house), use factors based on large objects would tend to underestimate wood use. Also, interior wall framing would tend to be overestimated since many additions do not have interior walls. Exterior and interior wall wood use factors were therefore converted from wood use per square foot of finished floor area to linear foot of wall built. Similar modifications and revisions were also made to new residential construction floor, roof, and millwork use factors as needed.

For room additions, estimates were stratified by region and major building component resulting in estimates of lumber, structural panels, and nonstructural panels used for floors, walls, roofs, and millwork by region. Total wood use for room additions in the United States was the sum of these individual components. Wood use per square feet of finished floor area was then calculated and compared to that for new residential construction. Overall, lumber and structural panel use per square foot of finished floor area was higher for room additions than for new single-family residential construction, and slightly lower for nonstructural panels (Fig. 8). The higher lumber and structural panel use factors were largely a result of the relative difference in size of the two types of structures, whereas the lower nonstructural panel use factor resulted from the type of rooms added. Large amounts of nonstructural panels were used for kitchen cabinets, bathroom vanities, and other millwork not present in many room additions.

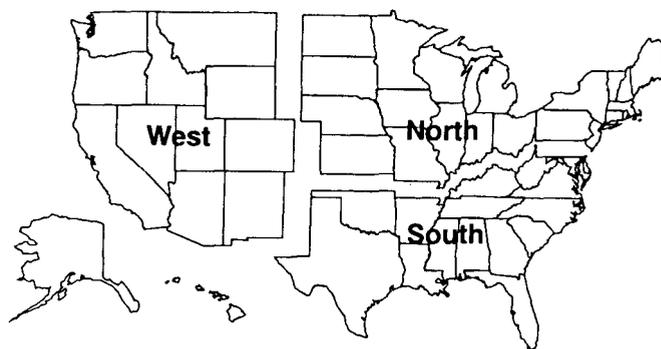


Figure 7—US. regions for room and garage additions.

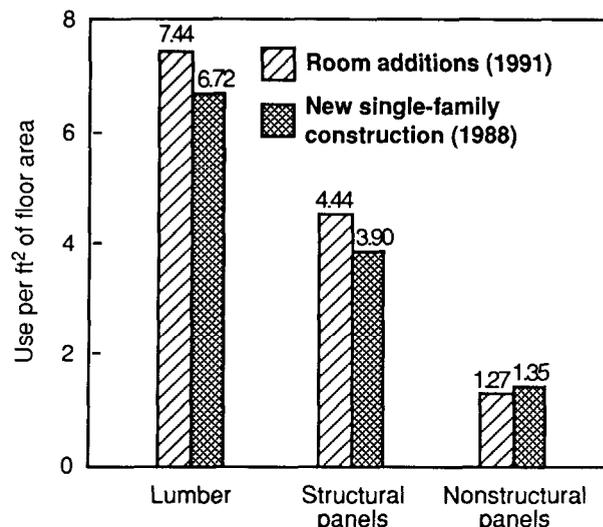


Figure 8—Wood use per square foot of finished floor area for room additions and new single-family construction. Lumber data are in board feet and panel data in square feet.

Wood Use by Region—Wood use by region closely followed expenditures for additions to structures by region. Based on 1987 expenditures by region from RISI (1989), an estimated one-half of all expenditures for additions to structures were in the North, 29 percent in the South, and 21 percent in the West in 1991. Relative to expenditures, room additions tended to use more lumber and structural panels in the North (57 percent lumber and 53 percent structural panels (Fig. 9)). Nonstructural panel use in the South and West was relatively more intensive than that in the North. About 12 percent of all structural panels used in the North and South were OSB/waferboard, compared to just 6 percent in the West. Actual lumber, structural panel, and nonstructural panel consumption by region is reported in Table 5.

Wood products use per \$1,000 of additions to structures expenditures paralleled trends in total wood use by region (Table 6). Lumber and structural panel use in the North was greater than the national average, whereas nonstructural panel use was lower. Just the opposite is true for the South

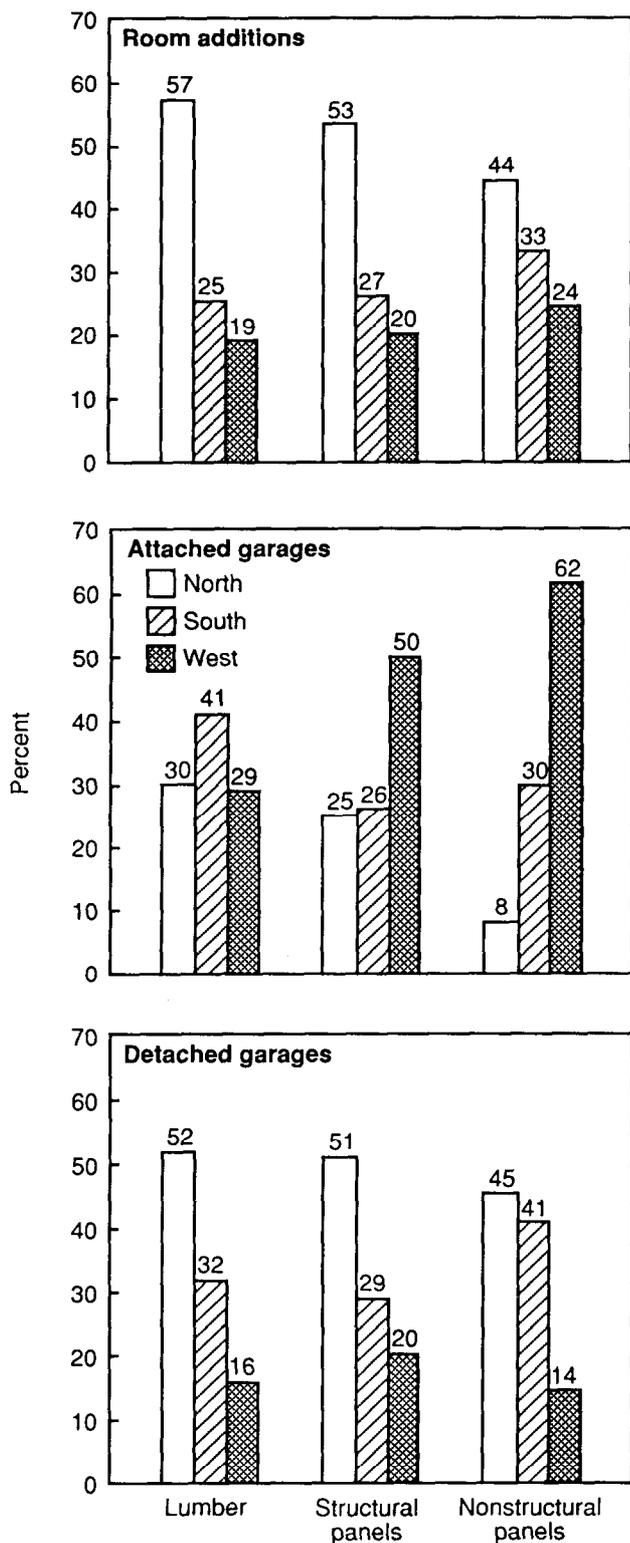


Figure 9—Regional percentage of wood use for room additions, attached garages, and detached garages, 1991.

and West-lumber and structural panel use was below the national average and nonstructural panel use was above this average. It is interesting to note that softwood plywood use per \$1,000 was lowest in the South, a major region for softwood plywood production.

Wood Use by Application—Nearly equal amounts of lumber were used to frame walls and roofs in room additions—1,129 and 1,080 million bf respectively (Table 5). Floor framing used less than one-half the amount of lumber (459 million bf) than either walls or roofs. Millwork used 197 million bf. Floor framing tends to use much less lumber than does wall or roof framing because nearly one-half of all room additions are built on concrete slab foundations. The use of a concrete slab foundation eliminates the need for a conventionally framed floor system, thereby reducing overall wood products consumption.

Structural panel consumption was greatest for roofs (705 million ft²), followed by floors (528 million ft²) and walls (440 million ft²) (Table 5). Structural panel use for millwork was very low, at just 48 million ft². The relative amounts of structural panels used by application are directly related to the incidence or frequency of structural panel use for specific applications. For example, 95 percent of all roofs had structural panel sheathing, making roof sheathing the single largest use for structural panels in room additions. Over one-half of all nonslab floors had a single layer of decking, nearly all constructed of structural panels. The remaining nonslab floors had double-layer floor decking, with about two-thirds constructed of structural panels. Even though wood floor systems accounted for just over one-half of all floor systems used, the relatively high incidence of structural panel decking resulted in floors ranking second in total structural panel use. Only about a third of all walls had structural panel sheathing and about a quarter had structural panel siding. As a result, wall systems used fewer structural panels than any other applications except millwork.

Nonstructural panel use was highest for walls primarily as a result of fairly high use of exterior siding. Total use for walls was 223 million ft² (Table 5). Millwork (doors, cabinets, and interior wall paneling) was the second highest use for nonstructural panels in room additions (186 million ft²). Lesser amounts were used for floors (78 million ft²) and roofs (11 million ft²).

Attached Garages

The addition of attached garages to existing structures required 215 million bf of lumber, 144 million ft² of structural panels, and 37 million ft² of nonstructural panels (Tables 3 and 5). Attached garages accounted for about 16 percent of garage additions built in 1991.

Attached garages are defined here to include new garages with one or more walls common to the existing residential structure, new carports attached to the existing residential structure, and enlargements of existing attached garages and carports. Lofts, storage areas, and other nonparking space included in the added structure are also included.

Of the 875.1 bf of lumber, 279.6 ft² of structural panels, and 75.7 ft² of nonstructural panels used per \$1,000 of

expenditure in 1991 for all additions to structures, attached garages accounted for just 3 percent (30.4 bf) of the lumber, 7 percent (20.4 ft²) of the structural panels, and 7 percent (5.2 ft²) of the nonstructural panels used.

As with room additions, standard building practices and codes are used for building garages and carports. Estimation of wood products use for attached garages followed closely the procedures described for estimating wood use for room additions. Also, building styles and preferences for garages and carports vary by region and affect wood products use. The data for attached garages were therefore stratified into North, South, and West regions.

Wood Use by Region-Although just 29 percent of expenditures for additions to structures were in the South in 1991, this region used 41 percent of the lumber for attached garages (Fig. 9). The remaining lumber was nearly equally divided between the North and South. Half the structural panels and nearly two-thirds the nonstructural panels were used in the West. The remaining structural panels used were nearly divided between the North and South. Just 8 percent of the nonstructural panels were used in the North and 30 percent in the South. Actual lumber, structural panel, and nonstructural panel consumption by region are reported in Table 5; wood products use per \$1,000 of expenditure for additions to structures is reported in Table 6.

Wood Use by Application-Nearly two-thirds of all lumber for attached garages was used in roof systems, primarily for framing. This is not surprising since all attached garages have at least one wall in common with the residence, since lesser amounts of lumber are needed to frame the wall containing the bay doors, and since carports generally do not have conventionally framed walls. Most of the remaining lumber was used for wall framing; small amounts were used for lofts, storage areas, and millwork. Like lumber, about one-half the structural panels were used in roof systems. The remaining volume was used for wall sheathing and siding (28 percent), and loft and storage area floors (21 percent). Less than 1 percent was used for millwork, primarily bay door panels. More than two-thirds of the nonstructural panels were used in wall applications for sheathing and siding.

Decks

Additions of decks and porches to existing structures required 3,109 million bf of lumber and 113 million ft² of structural panels. No nonstructural panels were reported for decks (Table 3).

Decks are defined here to include new attached and free-standing decks, new attached porches added to an existing residence, and enlargements of existing decks and porches. Decks were made entirely from wood or from a combination of wood and nonwood materials. Poured concrete patios are excluded.

Reports on the incidence of deck and porch additions vary considerably in both magnitude and scope, making it difficult to precisely estimate the annual number of additions. Reports have been based on the percentage of all homeowners who added decks or patios (Home Improvement Research Institute 1990), the percentage of single-family homeowners who added wooden decks and porches (Ahluwalia 1990), the number of professional installations of patios, decks, and porches (Casson 1986) or just patios and decks (Qualified Remodeler 1990), and the dollar value of professionally sold patios and decks (Qualified Remodeler 1987). No estimates were found on the number of enlarged decks and porches.

Data from the RISI study reported that 3.6 million decks were added in 1987 (RISI 1989). Information from other sources indicates that between 3.0 and 3.5 million deck additions are built annually.

Estimates of wood products used for decks and porches in the study reported here are based on the addition of an estimated 3.25 million decks annually. Compared to all additions to structures, deck additions accounted for 50 percent (439.6 bf) of the lumber and 6 percent (15.9 ft²) of the structural panels used per \$1,000 of expenditures. The typical deck addition averaged just under 300 ft² of floor area, and used about 3.25 bf of lumber and 0.12 ft² of structural panels per square foot of floor area. These usage rates include the wood required to build the deck itself (posts, framing, and decking) as well as the wood used for stairs, railings, benches, flower boxes, overhead lattice, sun screening, and other accessories.

Attic Conversions

The conversion of existing attic space into living space required an estimated 186 million bf of lumber, 502 million ft² of structural panels, and 88 million ft² of nonstructural panels. The typical conversion averaged 510 ft² of floor area and used 0.61 bf of lumber, 1.65 ft² of structural panels, and 0.29 ft² of nonstructural panels per square foot of floor area. These usage rates include the wood required for floor and wall framing, decking, and sheathing; for doors, windows and other millwork; and for miscellaneous uses.

Attic conversions are alterations made to existing attic space to change its use. Conversions can be as simple as creating storage space by adding a floor to an attic, to as complex as making one or more rooms by adding walls, floors, ceilings, and stairways. The addition of dormers and windows to an existing attic is also included. In general, conversions that change or add to the roof are included, while conversions where the entire roof is raised to create new space are excluded. These excluded projects are considered room additions.

Expenditures for attic conversions are included with expenditures for alterations to structures. Wood use per \$1,000 of expenditure for alterations to structures averaged 132.9 bf of lumber, 74.5 ft² of structural panels, and 140.6 ft² of nonstructural panels. Attic conversions accounted for 10 percent of the lumber (13.0 bf), 47 percent of the structural panel (35.0 ft²), and 4 percent of the nonstructural panel (6.2 ft²) use per \$1,000 of expenditure.

Basement Conversions

The conversion of existing basements into living space required an estimated 388 million bf of lumber, 44 million ft² of structural panels, and 156 million ft² of nonstructural panels. The typical conversion averaged 434 ft² of floor area and required 1.33 bf of lumber, 0.15 ft² of structural panels, and 0.54 ft² of nonstructural panels per square foot of floor area. These usage rates include the wood required for floor and wall framing, decking and sheathing; for doors, paneling, and other millwork; and for miscellaneous uses.

Basement conversions include alterations to existing basements to change its use. Conversions typically involve finishing the basement to create living space through the addition of floors, walls, and/or ceilings. Excavation under an existing structure to add basement space or finishing of basements built with room additions are not included. These excluded projects are considered room additions.

Expenditures for basement conversions are included with expenditures for alterations to structures. Basement conversions accounted for 20 percent of the lumber (27.0 bf), 4 percent of the structural panel (3.1 ft²), and 8 percent of the nonstructural panel (10.8 ft²) use per \$1,000 of expenditure.

Paneling

The addition of wood-based paneling to existing walls required an estimated 68 million bf of lumber, 50 million ft² of structural panels, and 297 million ft² of nonstructural panels. All structural panels were softwood plywood; no OSB/waferboard use was reported.

Paneling additions are defined here as projects in which the installation of paneling was the primary activity. The addition of paneling during room additions, room conversions, or other types of remodeling are included with the specific remodeling project.

Expenditures for paneling additions are included with expenditures for alterations to structures. Paneling additions accounted for 4 percent of the lumber (4.8 bf), 5 percent of the structural panel (3.5 ft²), and 15 percent of the nonstructural panel (20.6 ft²) use per \$1,000 of expenditure for alterations to structures.

Shelving

Shelving projects required an estimated 131 million bf of lumber, 116 million ft² of structural panels, and 371 million ft² of nonstructural panels. All structural panels were softwood plywood; no OSB/waferboard use was reported. Shelving projects include only those projects where the addition of shelving was the primary activity.

Expenditures for shelving projects are included with expenditures for alterations to structures. Shelving accounted for 7 percent of the lumber (9.1 bf), 11 percent of the structural panel (8.1 ft²), and 18 percent of the nonstructural panel (25.9 ft²) use per \$1,000 of expenditure for alterations to structures.

Kitchen and Bathroom Remodeling

The remodeling of kitchens and bathrooms required an estimated 189 million bf of lumber, 39 million ft² of structural panels (all softwood plywood), and 668 million ft² of nonstructural panels. Such remodeling projects can include simple replacement of a bathroom vanity; complete removal and replacement of cabinets, fixtures, and wall and floor coverings; replacement of doors and windows; and addition or removal of walls. Kitchen and bathroom remodeling was differentiated from other room remodeling because kitchens and bathrooms typically use different types of materials. For example, large amounts of nonstructural panels typically used in kitchen cabinets and other millwork are not used in other rooms. Also, finished floor coverings in kitchens and bathrooms typically require the addition of a floor underlayment.

Expenditures for kitchen and bathroom remodeling projects are included with expenditures for alterations to structures. Kitchen and bathroom remodeling accounted for 10 percent of the lumber (13.2 bf), 4 percent of the structural panel (2.7 ft²), and 33 percent of the nonstructural panel (46.5 ft²) use per \$1,000 of expenditure.

Other Room Remodeling

The remodeling of rooms other than kitchens and bathrooms required an estimated 335 million bf of lumber, 44 million ft² of structural panels (all softwood plywood), and 202 million ft² of nonstructural panels. Remodeling projects are major changes to an existing room. Activities include painting, papering, and paneling walls; adding or removing doors or windows; and adding or removing interior partitions. Unlike kitchen and bathroom remodeling, other room remodeling typically does not involve the installation of cabinets, hence the lower use of nonstructural panels.

Expenditures for other room remodeling projects are included with expenditures for alterations to structures and accounted for 18 percent of the lumber (23.3 bf), 4 percent of the structural panel (3.0 ft²), and 10 percent of the nonstructural panel (14.1 ft²) use per \$1,000 of expenditure.

Miscellaneous Home Projects

Miscellaneous home projects required an estimated 611 million bf of lumber, 277 million ft² of structural panels, and 237 million ft² of nonstructural panels.

Miscellaneous home projects include a wide range of activities that are typically done by the homeowner or that do not fit into specific project types. Examples include painting and papering walls, building cabinets and furniture, replacing millwork, and building a closet. Projects were included if the homeowner purchased the materials and did the work, or if the projects were not included in other project types. Thus, the construction of a basement storage closet would be considered a miscellaneous home project, but the construction of an entire room in the basement would be considered a basement conversion. This definition, while somewhat arbitrary, adequately describes this segment of the repair and remodeling market.

Expenditures for miscellaneous home projects are included with expenditures for alterations to structures and accounted for nearly 32 percent of the lumber (42.5 bf), 26 percent of the structural panel (19.3 ft²), and 12 percent of the non-structural panel (16.5 ft²) use per \$1,000 of expenditure.

Additions and Alterations Apart From Structures

Expenditures for additions and alterations apart from structures totaled \$6,214 million—about 22 percent of all expenditures for additions and alterations, and 7 percent of all residential repair and remodeling expenditures. Expenditures for additions and alterations were not separated. Expenditures translate into 3,713 million bf of lumber, 1,348 million ft² of structural panels, and 222 million ft² of nonstructural panels.

Projects included add new space or enlarge existing space for tool and storage sheds, detached garages, or other buildings detached from the residence, or add or modify landscaping, fences, other exterior nonbuilding structures, or other miscellaneous home projects. The projects all have the potential for using wood products and were examined in detail. Other types of projects that typically do not use wood products, such as building a swimming pool or tennis court, were not examined. As a group, addition and alterations apart from structures used 25 percent of the lumber, 20 percent of the structural panels, and 6 percent of the nonstructural panels used for all residential repair and remodeling.

Fences

An estimated 1,037 million bf of lumber and 48 million ft² of structural panels (all softwood plywood) were used for fencing. Included are wood fences produced at

manufacturing facilities, custom-built wood fences, wood posts, gates, and other fence-related items used to enclose property or space, such as a dog kennel. No nonstructural panels were reported for fences.

Expenditures for fencing projects are part of expenditures for additions and alterations apart from structures. Wood products use per \$1,000 of expenditure for all projects in this category was 597.4 bf of lumber, 216.9 ft² of structural panels, and 35.6 ft² of nonstructural panels. Fencing projects accounted for 28 percent of the lumber (166.8 bf) and 4 percent of the structural panel (7.7 ft²) use.

Landscaping

Landscaping projects required 812 million bf of lumber. Landscaping projects typically use railroad ties, landscaping timbers, and dimension lumber of various sizes. About one-fourth of the lumber used was railroad ties. The rest was treated and untreated landscaping timbers and dimension lumber. Eighty-eight percent of the lumber was treated; of this, 80 percent was treated with copper-chrome-arsenate (CCA). No structural or nonstructural panels were used for landscaping projects.

Landscaping projects accounted for 22 percent of the lumber (130.6 bf) use per \$1,000 of expenditure for additions and alterations apart from structures.

Sheds

The construction of sheds and other detached out-buildings required 591 million bf of lumber, 526 million ft² of structural panels, and 22 million ft² of nonstructural panels. Sheds are defined here to include storage sheds, tool sheds, and a wide variety of structures built on the property but detached from the residential structure. Detached garages are reported in another section. Included are sheds preassembled and transported as a single unit to the site, constructed from a kit or in component form and erected on the site, or completely constructed on-site.

Expenditures for sheds are included with expenditures for additions and alterations apart from structures. Shed construction accounted for 16 percent of the lumber (95.2 bf), 39 percent of the structural panel (84.7 ft²), and 10 percent of the nonstructural panel (3.5 ft²) use per \$1,000 of expenditure.

Detached Garages

Detached garages are defined here to include new garages with no adjoining walls to the residential structure, new free-standing carports, and enlargements of existing detached garages and carports. Lofts, storage areas, and other non-parking space included in the added structure are also considered in this category.

The addition of detached garages required 1,009 million bf of lumber, 654 million ft² of structural panels, and 98 million ft² of nonstructural panels. Detached garages accounted for 84 percent of the estimated 586,000 garage additions; the remainder were attached garages.

Of the 597.4 bf of lumber, 216.9 ft² of structural panels, and 35.6 ft² of nonstructural panels used per \$1,000 of expenditure in 1991 for all additions and alterations apart from structures, detached garages accounted for 27 percent (162.4 bf) of the lumber, 49 percent (105.2 ft²) of the structural panels, and 44 percent (15.7 ft²) of the nonstructural panels.

As with room additions and attached garages, standard building practices and codes are generally used for detached garages and carports. Estimation of wood products use therefore followed closely the procedures described for estimating wood use for room additions and attached garages. Also, building styles and preferences for garages and carports vary by region and affect wood products use. Detached garage data were therefore stratified into North, South, and West regions.

Wood Use by Region-Just over one-half the lumber and structural panels and nearly one-half (45 percent) the nonstructural panels used for detached garages occurred in the North (Fig. 9), seconded by use of all wood products in the South. Nonstructural panel consumption in the South was nearly equal to that in the North. Far less wood was used for detached garages in the West compared to the other regions.

Wood Use by Application-Nearly two-thirds (62 percent) of all lumber for detached garages was used in roof systems, primarily for framing, partially because lesser amounts of lumber are needed to frame the wall containing the bay doors and because carports lack conventionally framed walls. Most of the remaining lumber was used for wall framing (36 percent), with small amounts (less than 3 percent in total) used for lofts, storage areas, and millwork. Structural panels were also primarily used in roof systems, accounting for 56 percent of total use. The remaining volume was used for wall sheathing and siding (39 percent), loft and storage area floors (5 percent), and millwork (less than 0.5 percent). More than two-thirds of the nonstructural panels were used in wall applications for sheathing and siding.

Miscellaneous Home Projects

Miscellaneous home projects required an estimated 264 million bf of lumber, 120 million ft² of structural panels, and 102 million ft² of nonstructural panels.

Projects include activities typically done by the homeowner or not included in specific project types. See Miscellaneous Home Projects in Additions and Alterations to Structures for a more detailed description. Some typical miscellaneous home projects include dog houses, bird feeders, picnic tables, and playground equipment.

Expenditures for miscellaneous home projects, which are included with expenditures for additions and alterations apart from structures, accounted for 7 percent of the lumber (42.5 bf), 9 percent of the structural panel (19.3 ft²), and 46 percent of the nonstructural panel (16.5 ft²) use per \$1,000 of expenditure.

Major Replacements

Expenditures for major replacements totaled \$14,963 million-more than 17 percent of all residential repair and remodeling expenditures. Expenditures for major replacements translate into 1,144 million bf of lumber, 1,087 million ft² of structural panels, and 205 million ft² of nonstructural panels.

Projects include replacing an entire roof, installing new siding, and replacing doors and windows. These projects all have the potential for using wood products and were examined in detail. Other types of projects that typically do not use wood products, such as replacing a water heater or furnace, or re-wiring the entire structure, were not examined. Kitchen cabinet and bathroom vanity replacements were included with kitchen and bathroom remodeling because remodeling typically accompanies cabinet replacement. As a group, major replacements used 8 percent of the lumber, 17 percent of the structural panels, and 6 percent of the nonstructural panels used for all residential repair and remodeling.

Re-roofing

The re-roofing of existing structures required 585 million bf of lumber and 725 million ft² of structural panels. No nonstructural panel use was reported. Re-roofing is defined here as the complete replacement of the roof covering, including repairs to the sheathing, framing, fascia, and soffit. Also included is conversion of flat to pitched roofs. Projects in which only a portion of the roof was replaced or repaired are considered within maintenance and repairs and are not included here, nor is roofing associated with additions and alterations.

Expenditures for re-roofing projects are not reported separately but as part of expenditures for major replacements. Wood products use per \$1,000 of expenditure for all major replacements was 76.5 bf of lumber, 72.7 ft² of structural panels, and 13.7 ft² of nonstructural panels; re-roofing projects accounted for 51 percent of the lumber (39.1 bf) and 67 percent of the structural panel (48.4 ft²) use.

Re-siding

The re-siding of existing structures required 317 million bf of lumber, 361 million ft² of structural panels, and 135 million ft² of nonstructural panels. Softwood plywood and OSB siding were not separated. Re-siding is defined as

the complete replacement of the existing exterior wall covering, including fascia, soffit, and other siding-related components. Repairs to the sheathing and framing during the re-siding project are also included, as is the installation of additional sheathing for insulation or for providing a smooth surface for the new siding. Siding installed during additions and alterations is not included here.

Expenditures for re-siding projects are included with expenditures for major replacements. Wood products use for re-siding accounted for 28 percent of the lumber (21.2 bf), 33 percent of the structural panel (24.1 ft²), and 66 percent of the nonstructural panel (9.0 ft²) use per \$1,000 of expenditure.

Replacement of Doors and Windows

The replacement of doors and windows in existing structures required an estimated 242 million bf of lumber, 2 million ft² of structural panels (all softwood plywood), and 70 million ft² of nonstructural panels. All panels, structural and nonstructural, were used for door panels, skins, and cores. Sixty percent of the lumber was used for door and window frames, door panels, door jambs, and other millwork; 40 percent was used for framing modifications for installing the new doors and windows. Door and window replacements include the replacement of existing exterior doors and windows, interior doors, related millwork, and framing lumber needed to install the doors and windows. As with other major replacements, the replacement of doors and windows or installation of new doors and windows done in conjunction with additions and alterations is not included here.

Expenditures for door and window replacements are included with expenditures for major replacements. Wood products use for door and window replacements accounted for 21 percent of the lumber (16.2 bf), less than one-half of 1 percent of the structural panel (2 ft²), and 34 percent of the nonstructural panel (4.7 ft²) use per \$1,000 of expenditure.

Maintenance and Repairs

Expenditures for maintenance and repairs totaled \$44,540 million. This is larger than any single type of residential repair and remodeling expenditure, and more than one-half of all expenditures for residential repair and remodeling. Although large, expenditures for maintenance and repairs translate into just 1,978 million bf of lumber, 1,116 million ft² of structural panels, and 734 million ft² of nonstructural panels.

Maintenance and repairs include a wide variety of activities needed to maintain a property in working condition. Plumbing, electrical, and heating repairs are included, as are routine maintenance activities. Few activities require the use of lumber or wood products. However, two project types were identified that require substantial amounts of wood products: roof repairs and miscellaneous home projects. Both these projects were examined in detail. As a group, they used 13 percent of the lumber, 17 percent of the structural panels, and 20 percent of the nonstructural panels used for all residential repair and remodeling.

Roof Repairs

Repairs to roofs of existing structures required an estimated 85 million bf of lumber and 258 million ft² of structural panels. No nonstructural panel use was reported. Roof repairs are defined as repairs to the exterior roof covering, framing and sheathing, and fascia and soffit. The replacement of the entire roof and the roofing of additions and alterations are included with major replacements and additions and alterations, respectively.

Expenditures for roof repairs are included with expenditures for maintenance and repairs. Wood products use per \$1,000 for all maintenance and repairs was 44.4 bf of lumber, 25.1 ft² of structural panels, and 16.5 ft² of nonstructural panels. Roof repair projects accounted for 4 percent of the lumber (1.9 bf) and 23 percent of the structural panel (5.8 ft²) use per \$1,000 of expenditure.

Miscellaneous Home Projects

Miscellaneous home maintenance and repair projects required an estimated 1,893 million bf of lumber, 857 million ft² of structural panels, and 734 million ft² of nonstructural panels.

Miscellaneous home projects include a wide range of activities and are described in more detail in the Miscellaneous Home Projects section of Additions and Alterations to Structures. Any repair and maintenance projects that required the use of wood products, with the exception of roof repairs, are included here.

Expenditures for miscellaneous home projects are included with expenditures for Maintenance and Repairs and accounted for 96 percent of the lumber (42.5 bf), 77 percent of the structural panel (19.3 ft²), and 100 percent of the nonstructural panel (16.5 ft²) use per \$1,000 of expenditure.

Conclusions

The repair and remodeling of residential properties in the United States is a large, dynamic market for lumber, wood panels, and manufactured wood products. In 1991, \$97,528 million was spent (\$87,156 million, constant 1987 dollars), resulting in the consumption of 14,934 million bf of lumber, 6,599 million ft² of structural panels, and 3,716 million ft² of nonstructural panels. Expenditures for residential repair and remodeling were nearly evenly divided between the categories of improvements and maintenance and repairs, with wood products heavily weighted towards improvements (about 85 percent of all wood products).

The most intensive wood-using expenditure type was additions to structures. More lumber and structural panels were used for additions to structures than any other expenditure type; room addition projects were the single largest wood end-use market in residential repair and remodeling. In 1991, the wood used in room additions could have built approximately 200,000 new houses.

The outlook for continued strength in the residential repair and remodeling market in the United States is good. Many factors that caused an upsurge in expenditures for repair and remodeling in the mid-1980s are still in effect today, including rising family incomes, aging of the Nation's housing stock, and rising new house construction costs. Information from this study can help land managers provide the raw materials, and producers and manufacturers target this important market for wood products.

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Appendix

Procedures

The consumption of wood products for residential repair and remodeling is largely determined by four components: (1) level of repair and remodeling activity, (2) type of repair and remodeling projects, (3) project characteristics, and (4) amount of wood products used per unit of project activity. This study was designed to use existing information from published and unpublished sources. A limited amount of new information was collected to answer specific questions or to verify results. Information on expenditures for residential repair and remodeling from the U.S.

Department of Commerce, Bureau of the Census (1992) was used to measure the level of repair and remodeling activity for specified expenditure types. Information on types and characteristics of residential repair and remodeling projects done in 1987 was purchased from George Carter & Affiliates, Oradell, New Jersey. This information was collected as part of a proprietary study conducted by Resource Information Systems, Inc. on wood products used in residential repair and remodeling in 1987 (RISI 1989).

Information on the amount of wood used per unit of activity for building applications was developed from information collected for a new residential construction study recently published by the American Plywood Association (APA) for the Wood Products Promotion Council (Anderson and McKeever 1991). Additional information was obtained from published trade journal articles, from information collected specifically for this study by the APA from contractors who participate in the APA Code Plus program, and from discussions with the following persons: Gopal Ahluwalia, National Association of Home Builders, Washington, DC; Craig Adair, APA, Tacoma, Washington; Fred Reseberg, Western Wood Products Association, Seattle, Washington; and David Sauer, *Qualified Remodeler* magazine, Chicago, Illinois. Note: The APA Code Plus program is designed for residential builders and remodelers who use structural panels in roofs, walls, and floors. For additional information on this program, contact the American Plywood Association, P.O. Box 11700, 7011 South 19th Street, Tacoma, Washington 98411.

Using the information from these sources, wood products consumption for residential repair and remodeling can be estimated through a four-step process:

1. Define the overall residential repair and remodeling market, identify major types of activities within the market that have similar characteristics (expenditure types), and define specific project types within each major expenditure type that potentially use wood products.
2. In each project type, acquire data from a representative sample of households in which the specified repair or

remodeling activity was undertaken in a specified year. Data must include the cost of the activity and other characteristics that can be used to estimate the frequency of wood products use.

3. Develop factors of wood use per unit of activity specific to each project type, estimate wood products consumption for each sampled household, and add the data from all households within each project type.
4. Expand wood products consumption in the base year from the household sample to the United States for each project type, develop factors of wood use per \$1,000 of expenditure, estimate wood products consumption by project type in 1991 using these factors, and add the data from all project and expenditure types.

Step I-Market Definition

The residential repair and remodeling market is defined by the U.S. Department of Commerce, Bureau of the Census, as improvements and repairs made by property owners for residential properties in the 50 states and the District of Columbia. Included are single- and multiunit structures, publicly and privately owned structures, farm and nonfarm properties, and residential properties occupied by owners or renters, or vacant. In general, improvements and repairs must be permanently attached and firmly affixed, or permanently associated with the property. Overall activity in the residential repair and remodeling market is defined in terms of expenditures for improvements and repairs, measured in current dollars. Overall activity is divided into groups of activities with similar characteristics (text, Fig. 1). Total expenditures and expenditures for each expenditure type are reported annually. These expenditures are the only statistically reliable, consistent set of national data for residential repair and remodeling. Detailed definitions can be found in the 1992 U.S. Department of Commerce, Bureau of the Census report.

The U.S. Department of Commerce, Bureau of the Census definitions of the U.S. residential repair and remodeling market were used in this study, as were reported current dollars of expenditure, by expenditure type. Within each expenditure type, individual repair and remodeling projects that potentially require the use of wood products were defined. Seventeen such project types were defined in the 1987 RISI repair and remodeling study. These project types formed the basis of the project types used in the study reported here with the following exceptions. Insulation projects were not included because wood product use is typically not required. Garage addition projects were divided into attached and detached garage additions to permit inclusion in the appropriate expenditure types. Roofing projects were divided into re-roofing and roof repair projects to permit inclusion in the appropriate expenditure types. Miscellaneous home projects were divided into three projects

and distributed over three expenditure types based on the types of activities included. These modifications to the RISI project types resulted in 20 project types. In the text, Figure 4 shows each project type and the associated expenditure type.

Step 2—Data Acquisition

Once the structure of the residential repair and remodeling market is defined, actual data must be acquired to describe projects and estimate wood products consumption. Since the use of wood products for residential repair and remodeling is determined to a large part by the types and sizes of projects, reliable information must be acquired on both expenditures and characteristics of projects completed within each project type for a specified year. These sample data describe the characteristics of each project in detail and provide the basis from which to estimate wood products consumption in each specific application. An application is a specific task undertaken or identifiable component in a repair and remodeling project. Application examples include exterior wall framing in room or garage additions, bathroom vanities in bathroom remodeling projects, and roof sheathing in roof repair projects. Data collected by George Carter & Affiliates for the 1987 RISI repair and remodeling study were used in our study for the following reasons: (1) the data were originally collected using a statistically designed sampling procedure to ensure reliability of results, (2) the detailed expenditure and characteristic data were needed to estimate wood products consumption by application, (3) relationships between expenditures, project characteristics, and wood use were fairly constant between 1987 (the base year of the RISI study) and 1991 (the base year for this study), and (4) resources were not available to conduct a new nationwide survey of households.

The RISI data were modified to reflect project types used in this study (see Step 1) and were entered into a computer database for further analysis. Table 8 shows representative expenditure, project, and application characteristics from this database for exterior walls built for room additions in 1987.

Step 3—Sample Wood Use Estimation

The next step in the analysis was the estimation of wood products consumption for each household respondent. Data on individual characteristics were first edited to resolve conflicts caused by missing or incomplete, contradictory, or erroneous data. Details of how these conflicts were resolved are described in the section on missing data. Next, factors defining typical amounts of wood used by type of wood product and application were developed. These factors describe the amount of a specific wood product (e.g., 2 by 4 in. lumber) needed per unit of activity (linear feet) for each application (exterior wall framing). Data from a variety of sources were used to develop the wood use factors.

Information from a recently completed study of wood products for new residential construction was used to develop wood use factors for much of the room and garage addition data, as well as for other building projects (Anderson and McKeever 1991). Since standard building codes and practices apply to both new construction and to repair and remodeling, these factors were deemed appropriate. Information from trade journals, trade associations, and other sources was used in conjunction with observed, typical patterns of wood use to develop wood use factors for applications not covered by the new residential study. For example, a weighted average volume of lumber used per linear foot of exterior deck railings was used to estimate lumber use based on reported characteristics of deck railings. Table 9 shows characteristics, lumber use factors, and estimated amounts of lumber used to frame exterior walls in room addition projects.

Similar calculations were made for each application. Wood use was then summed over all applications and households in each project, resulting in estimated amounts of wood products used by project type for the household sample. For room and garage additions, wood use was not summed over all applications and households, but over similar applications and regions, resulting in estimated wood products use for floors, walls, roofs, and millwork in the North, South, and West. This level of detail for room and garage additions was maintained because of the importance of these project types to overall wood use and so that comparisons with new residential construction could be made.

Step 4—Total U.S. Wood Use Estimation

The final step in the analysis was the estimation of total wood use based on use in the sampled households. First, sample wood use in each project type was divided by the total cost of the projects. This resulted in factors that defined wood use per \$1,000 of cost for the sampled households in each project type in 1987. These factors were then multiplied by RISI estimated costs for the population as a whole in 1987 for each project type for two reasons: (1) because RISI estimates are consistent with the wood use data and (2) because such data by project type are not available from the U.S. Department of Commerce. Table 10 shows estimated sample and population wood products use for wall systems applications and for all applications in room additions built in the North and in the United States as a whole in 1987.

Next, estimated population wood use by project type was assigned to appropriate expenditure types as defined by the U.S. Department of Commerce, Bureau of the Census (1992) (Fig. 4). Wood use was then divided by 1987 U.S. Department of Commerce, Bureau of the Census expenditures by expenditure type. This calculation resulted in factors that define the amount of wood used per \$1,000 for each wood product and project type in each expenditure type (Table 11). These factors also measure the relative

Table 8—Representative characteristics and costs for exterior walls built for room additions^a

| Project costs | | | Outside dimensions | | Exterior wall characteristics | | | | |
|-----------------------------|-------|-------|--------------------|-------|-------------------------------|-----------------------|-----------------------|-----------|--------------|
| Material | Labor | Total | Attachment length | Depth | Estimated floor area | Estimated wall length | Stud size and spacing | Sheathing | Siding |
| ---- (thousand U.S. \$)---- | | | (ft) | (ft) | (ft ²) | (ft) | | | |
| 0.6 | 0.0 | 0.6 | 12 | 12 | 144 | 36 | — | Foam | Cement block |
| 1.2 | 0.6 | 1.8 | 12 | 4 | 48 | 20 | 2x4/16 | OSB/foam | Shingles |
| 2.5 | 0.0 | 2.5 | 25 | 12 | 300 | 49 | 2x4/16 | — | — |
| 1.3 | 0.0 | 1.3 | 22 | 4 | 88 | 30 | — | Plywood | Other |
| 3.0 | 0.0 | 3.0 | 16 | 12 | 192 | 40 | 2x4/16 | Ply/foam | Lumber |
| 4.0 | 11.0 | 15.0 | 20 | 13 | 260 | 46 | — | — | Brick |
| 0.3 | 0.0 | 0.3 | 9 | 4 | 36 | 17 | 2x4/16 | Foam | Brick |
| 5.0 | 0.0 | 5.0 | 16 | 10 | 160 | 36 | 2x4/16 | Foam | Aluminum |
| 1.9 | 1.3 | 3.2 | 20 | 18 | 360 | 56 | 2x6/16 | Ply/foam | Vinyl |
| 12.0 | 8.0 | 20.0 | 22 | 16 | 352 | 54 | 2x4/16 | Plywood | Vinyl |
| 7.5 | 2.5 | 10.0 | 20 | 17 | 340 | 54 | 2x4/16 | — | — |
| 1.4 | 0.0 | 1.4 | 14 | 12 | 168 | 38 | 2x6/24 | Plywood | Plywood |
| 5.0 | 2.5 | 7.5 | 20 | 8 | 160 | 36 | 2x4/16 | Plywood | Shingles |
| 2.5 | 0.0 | 2.5 | 12 | 12 | 144 | 36 | 2x4/16 | OSB | Other |

^aData from RISI, modified to reflect project types. All additions were single-story and were built in the North. 1 ft = 0.3 m.

Table 9—Lumber for exterior wall framing in room additions^a

| Estimated wall length | Wood framed walls | Estimated stud size and spacing | | | | Lumber use per LF wall | Total lumber used |
|-----------------------|-------------------|---------------------------------|--------|--------|--------|------------------------|-------------------|
| | | 2x4/16 | 2x4/24 | 2x6/16 | 2x6/24 | | |
| (ft) | | | | | | (bf) | (bf) |
| 36 | 0 | — | — | — | — | 0.00 | 0 |
| 20 | 1 | 1 | — | — | — | 10.10 | 202 |
| 49 | 1 | 1 | — | — | — | 10.10 | 495 |
| 30 | 1 | — | — | — | — | 11.02 | 331 |
| 40 | 1 | 1 | — | — | — | 10.10 | 404 |
| 46 | 1 | — | — | — | — | 11.02 | 507 |
| 17 | 1 | 1 | — | — | — | 10.10 | 172 |
| 36 | 1 | 1 | — | — | — | 10.10 | 364 |
| 56 | 1 | — | — | 1 | — | 14.84 | 831 |
| 54 | 1 | 1 | — | — | — | 10.10 | 546 |
| 54 | 1 | 1 | — | — | — | 10.10 | 546 |
| 38 | 1 | — | — | — | 1 | 11.13 | 423 |
| 36 | 1 | 1 | — | — | — | 10.10 | 364 |
| 36 | 1 | 1 | — | — | — | 10.10 | 364 |

^aData from RISI, modified to reflect project types. All additions were single-story and were built in the North. 1 ft = 0.3 m. LF is linear foot.

Table 10—Wood products use in wall applications and other applications

| Region | Total floor area added (ft ²) | Project cost (1987\$) | Lumber (bf) | Wall applications | | | | Total, all applications | | | | |
|----------------------|--|--------------------------|----------------|--------------------------------|-----------------|--------|-----------------------|--------------------------------|-----------------|--------|-----------------------|---------|
| | | | | Structural panels | | | Non-structural panels | Structural panels | | | Non-structural panels | |
| | | | | Plywood | OSB-wafer-board | Total | | Plywood | OSB-wafer-board | Total | | |
| | | | | ----- (ft ²) ----- | | | | ----- (ft ²) ----- | | | | |
| North | | | | | | | | | | | | |
| Sample total | 45,119 | 1,478.9 | 137,580 | 37,420.1 | 0,153.4 | 7,573 | 18,188 | 367,148 | 180,437 | 23,958 | 204,39 | 48,917 |
| Sample average | 358 | 11.7 | 1,091.9 | 297.0 | 80.6 | 377.6 | 144.4 | 2,913.9 | 1,432.0 | 190.1 | 1,622.2 | 388.2 |
| Percent of sample | 56 | 59 | 8 | 49 | 71 | 52 | 40 | 61 | 56 | 62 | 57 | 48 |
| Per \$1,000 cost | — | — | 93.03 | 25.30 | 6.87 | 32.17 | 12.30 | 248.26 | 122.01 | 16.20 | 138.21 | 33.08 |
| Population (million) | — | 8,900.0 | 827.9 | 225.2 | 61.1 | 286.3 | 109.5 | 2,209.5 | 1,085.9 | 144.2 | 1,230.0 | 294.4 |
| United States | | | | | | | | | | | | |
| Sample total | 80,827 | 2,514.6 | 236,119 | 76,976 | 14,345 | 91,321 | 45,057 | 601,218 | 319,990 | 38,518 | 358,50 | 102,276 |
| Sample average | 327 | 10.2 | 955.9 | 311.6 | 58.1 | 369.7 | 182.4 | 2,434.1 | 1,295.5 | 155.9 | 1,451.5 | 414.1 |
| Percent of sample | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Per \$1,000 cost | — | — | 93.90 | 30.61 | 5.70 | 36.32 | 17.92 | 239.09 | 127.25 | 15.32 | 142.57 | 40.67 |
| Population (million) | — | 16,230.0 | 1,525.9 | 502.9 | 91.0 | 593.9 | 301.4 | 3,872.3 | 2,076.2 | 249.0 | 2,325.2 | 673.8 |

Table 11—Wood use per \$1,000 of expenditure for all project types included in additions to structures expenditure class

| Expenditure and project type | Structural panels | | | | | | | | | |
|------------------------------|-------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|----------------------|-----|
| | Lumber | | Softwood plywood | | OSB/waferboard | | Total | | Nonstructural panels | |
| | (bf) | (%) | (ft ²) | (%) |
| Room addition | 405.2 | 46 | 217.2 | 87 | 26.1 | 89 | 243.3 | 87 | 70.5 | 93 |
| Attached garage | 30.4 | 3 | 17.1 | 7 | 3.3 | 11 | 20.4 | 7 | 5.2 | 7 |
| Deck | 439.6 | 50 | 15.9 | 6 | 0.0 | 0 | 15.9 | 6 | 0.0 | 0 |
| Total | 875.1 | 100 | 250.3 | 100 | 29.3 | 100 | 279.6 | 100 | 75.7 | 100 |

contribution of each project type to wood use in the expenditure type. Table 11 shows wood use per \$1,000 of expenditure for all projects types included in additions to structures expenditure class.

Finally, expenditures in 1991 by type of expenditure (constant 1987 dollars) were multiplied by wood use per \$1,000 of expenditure for each project type in 1987, resulting in estimated wood products consumption, by product type, for each project and expenditure type. Wood use was then summed over all expenditure types, resulting in total U.S. wood products consumption for residential repair and remodeling. Estimated wood products consumption and use per \$1,000 of expenditure are reported in Tables 3, 5, and 6 of this report.

Missing Data

Every attempt was made to use as much of the RISI household survey data as possible. However, missing, inconsistent, erroneous, unreliable, or insufficient data are inevitable whenever large surveys are used to collect information from individual households. Different approaches were used to eliminate, correct, and augment missing or erroneous data.

First, other information from the individual household response was used to estimate erroneous or missing data. For example, if exterior wall framing was reported as 2- by 4-in. lumber and interior walls were reported as built but lumber framing size was not included, then 2- by 4-in. lumber was assumed.

If it was not possible to estimate missing or erroneous data from other information contained in the individual household response, standard building practices were assumed. For example, if exterior wall framing was reported as 2- by 4-in. but no stud spacing was reported, 16 in. spacing was assumed because this is the standard spacing for 2- by 4-in. studs.

If data for a single question across all respondents seemed erroneous as a result of misinterpretation of the question by the respondent, average characteristics from other studies, typical building practices or products, or other sources of information were used. For example, exterior wall sheathing was frequently reported as being particleboard. Since particleboard is not typically used for exterior sheathing, it was assumed that OSB/waferboard was the actual product used.

Finally, when the information on characteristics of individual projects was inadequate to reliably estimate wood products use, average characteristics from other studies, typical building practices or products, or other sources of information were used. For example, information on the

frequency of roof truss use was collected, but not the size or spacing of the truss for room and garage additions. Average roof truss characteristics from the new residential construction wood use study were used to estimate truss characteristics for these additions.

Overall, the characteristics data provided by George Carter and Affiliates were good. The data required only minor modifications to adequately describe individual repair and remodeling activities conducted in 1987.

Wood Products Consumption for Millwork

The estimates of total wood products used for residential repair and remodeling presented in this report include substantial volumes of lumber and wood panels contained in products used in these projects but premanufactured elsewhere. Products like kitchen cabinets and bathroom vanities, doors and windows, trim and moldings, interior wall and ceiling coverings, shelving, finished wood flooring, and wood roof shakes and shingles are made in industrial plants and shipped to the job site in finished or semifinished form. As such, these millwork products are usually accounted for in industrial or manufacturing wood use studies (for example, see McKeever and Martens 1983). Estimated volumes of lumber, structural panels, and nonstructural panels used for millwork for residential repair and remodeling are reported here by expenditure type. These estimates provide a convenient way to gauge the importance of industrial wood products to residential repair and remodeling, and their use can circumvent double-counting when comparing wood use in the residential repair and remodeling and the industrial end-use markets.

Wood use estimates for millwork products were based on the incidence of use, or frequency, of individual products in repair and remodeling projects, and on wood use per unit of product used. Factors of wood use per unit of millwork were based on information developed by Anderson and McKeever (1991) for new residential construction millwork use. These factors were deemed appropriate because few, if any, differences exist between millwork used for new residential construction and for residential repair and remodeling. The incidence of a particular millwork product may vary between new construction and repair and remodeling, but the materials used in the product do not vary. For example, a solid-core, exterior, wooden flush door with a particleboard core contains the same amounts of wood products regardless of its final destination.

Total Wood Use

An estimated 1,363 million bf of lumber, 380 million ft² of structural panels, and 2,043 ft² of nonstructural panels were

used in 1991 for millwork in residential repair and remodeling (Table 4). These volumes represent 9 percent of all lumber, 7 percent of all structural panels, and 55 percent of all nonstructural panels used for residential repair and remodeling. These percentages compare to 7 percent of all lumber, 1 percent of all structural panels, and 43 percent of all nonstructural panels in new residential construction being used for millwork (McKeever and Anderson 1992). Thus, millwork products are an important component of total wood products used for residential repair and remodeling, even more so than those used for new residential construction; more than one-half of all nonstructural panels are used for millwork.

Wood Use by Expenditure Type

More than 90 percent of all wood products for millwork were used for improvements to residential properties (Fig. 10). The remaining volume was used for maintenance and repairs. Alterations to structures was by the far the single most important expenditure type for wood use in millwork

products. Nearly one-half of the lumber, three-fourths of the structural panels, and more than four-fifths of the non-structural panels were used for alterations. This was not unexpected since the projects included in this expenditure type, such as adding shelving, adding paneling, remodeling kitchens and bathrooms, and finishing basements and attics, all use large amounts of millwork products. Wood use for millwork as a percentage of total wood use for alterations to structures was also much above the average for all expenditure types: approximately one-third of all lumber and structural panels, and more than four-fifths of all nonstructural panels (Table 4).

When additions to structures were combined with alterations to structures, percentage of wood use rose to 63 percent of the lumber, 87 percent of the structural panels, and 94 percent of the nonstructural panels used for all millwork products. No other expenditure type accounted for more than 8 percent of the wood used for millwork, with the exception of lumber for major replacements, primarily door and window replacements (28 percent).

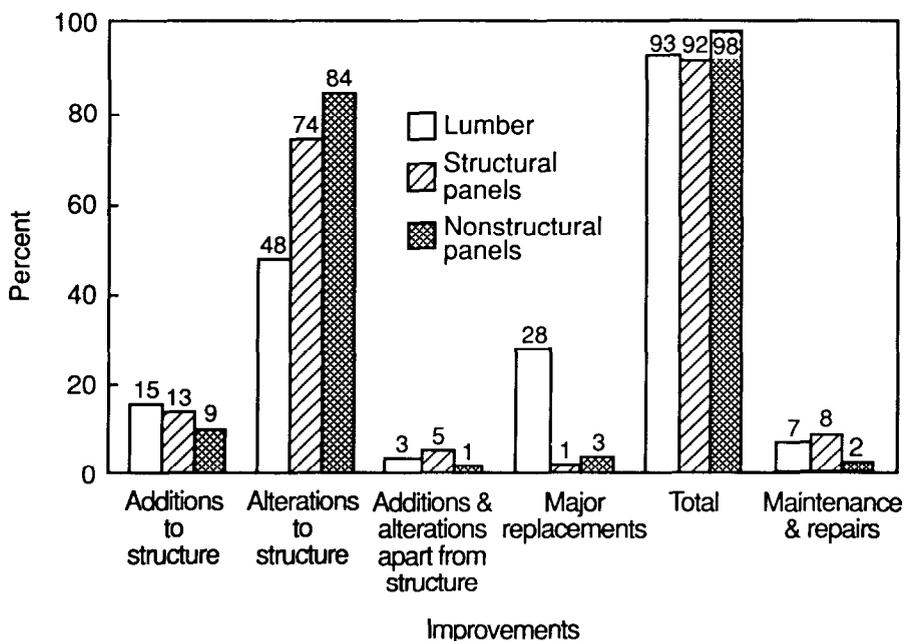


Figure 10—Wood use for millwork products as percentage of total millwork use for residential repair and remodeling, by expenditure type, 1991.